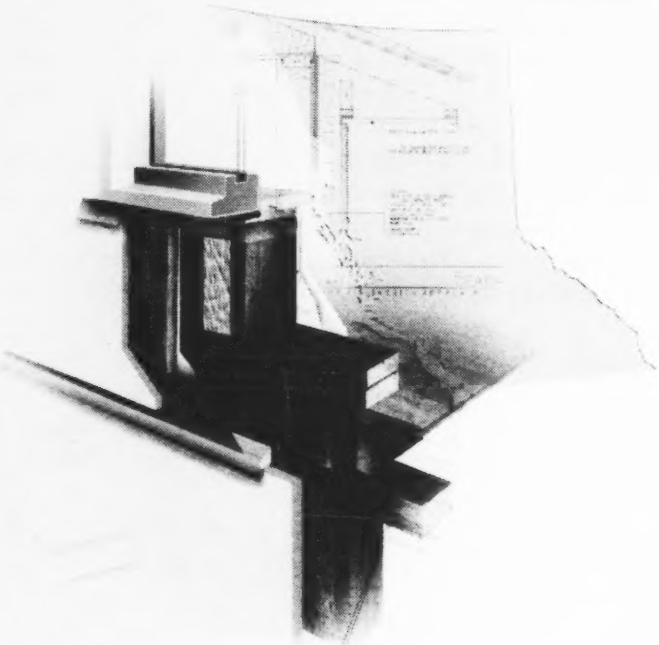
WOODFRAME ENVELOPES IN THE COASTAL CLIMATE OF BRITISH COLUMBIA

BEST PRACTICE GUIDE
BUILDING TECHNOLOGY



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The Canadian Wood Council encourages the use of *Best Guide for Wood-Frame Envelopes in the Coastal Climate of British Columbia* as a means of improving overall construction quality. The CAD drawings and explanations will contribute to a better understanding of building science issues that will assist designers and builders construct envelopes that are reliable, durable and economic.

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FOREWORD

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This publication is one of many items of information published by CMHC with the assistance of federal funds.

The Building Envelope Research Consortium (BERC) was instrumental in providing overall direction and guidance for the production of this document. BERC consists of representatives from a wide cross-section of the building construction community in British Columbia including architecture and engineering associations, research organizations, various levels of government, developers, contractors and product associations.

This *Best Practice Guide* is intended to be a living document and will be updated as feedback is received and as more current technical information becomes available. Users are invited to submit their comments and suggestions to:

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DISCLAIMER

The information contained in this publication represents current research results available to CMHC, and has been reviewed by a wide spectrum of experts in the housing industry. Readers are advised to evaluate the information, materials and techniques cautiously for themselves and to consult appropriate professional resources to determine whether information, materials and techniques are suitable in their case. The drawings and texts are intended as general practice guides only. Project and site-specific factors of climate, cost, aesthetics, and so on, must be taken into consideration.

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1 / INTRODUCTION

Background 1-1
Climate 1-1
The Best Practice Guide 1-3
Key Points 1-5
Margin Icons 1-6

2 / BEHAVIOUR OF WOOD IN CONSTRUCTION

Characteristics of Wood 2-1
Wood Framing Issues 2-8
Key Points 2-15

3 / CONTROLLING MOISTURE SOURCES

Moisture Balance 3-1
Exterior Sources 3-3
Interior Moisture Sources 3-13
Construction Moisture Sources 3-23
Deflection, Drainage and Drying 3-25
Key Points 3-26

4 / HEAT FLOW

Mechanisms of Heat Flow 4-1
Thermal Bridging Effects and Control 4-2
Thermal Performance Strategies and Requirements 4-3
Key Points 4-4

5 / ASSEMBLIES

System Requirements 5-1
Wall Assemblies 5-8
Roof Assemblies 5-19
Balcony / Walkway Assemblies 5-28
Window Assemblies 5-31

6 / DETAILS

General 6-1
Detail Drawings 6-3

7 / COMPONENTS AND MATERIALS

Scope 7-1
Wood Products 7-1
Insulation 7-4
Sheathing Membranes 7-5
Flashings 7-8

Eavestroughs and Rain Water Leaders 7-12
Cladding 7-13
Windows and Sliding Doors 7-20
Skylights 7-24
Doors 7-28
Sealants 7-29
Painting and Exterior Coatings 7-32
Water Shedding Roofing 7-35
Waterproof Roofing 7-37
Balcony and Walkway Pedestrian Traffic Membranes 7-40

8 / QUALITY ASSURANCE

Overview 8-1
Designing for Quality 8-1
Maintaining Quality 8-2
Key Points 8-2

9 / MAINTENANCE AND RENEWAL

Overview 9-1
Maintenance Planning 9-3
Renewal Planning 9-4
Key Points 9-5

REFERENCES R-1

GLOSSARY G-1

LIST OF FIGURES

Figure 1.1 Comparison of coastal and inland climates 1-2
Figure 2.1 Wood shrinkage and moisture content 2-1
Figure 2.2 Fibre saturation point and wood cell structure 2-2
Figure 2.3 Drying effects on cross-sectional shape 2-3
Figure 2.4 Drying effects on lengthwise shape 2-3
Figure 2.5 Relative humidity versus moisture content 2-5
Figure 2.6 Fungal growth in wood 2-7
Figure 2.7 Shrinkage at steel column 2-11
Figure 2.8 Shrinkage at fire wall 2-12
Figure 2.9 Shrinkage at balconies 2-13
Figure 2.10 Shrinkage at masonry veneer 2-14
Figure 3.1 Effect of overhang on wall performance 3-3
Figure 3.2 Wind pressures on buildings 3-7
Figure 3.3 Pressure difference–No compartmentalization 3-8
Figure 3.4 Pressure difference–Corner compartmentalization 3-9
Figure 3.5 Stack effect forces 3-15

Figure 3.6 Mechanical ventilation forces 3-16
Figure 5.1 Exposure category nomograph 5-4
Figure 7.1 'S' Lock joint 7-8
Figure 7.2 Standing seam joint 7-8
Figure 7.3 Flashing end dams 7-12
Figure 7.4 Relative durability of exterior coatings 7-15
Figure 7.5 Masonry base flashing 7-19
Figure 7.6 Typical insulated glazing unit 7-23
Figure 7.7 Typical unit skylight installation 7-26
Figure 7.8 Typical T-bar skylight 7-27
Figure 7.9 Pressure equalized rainscreen skylight 7-29
Figure 7.10 Typical sealant profiles 7-33
Figure 8.1 Quality assurance pyramid 8-1
Figure 9.1 35-year life cycle costs 9-1

LIST OF TABLES

Table 2.1 Longitudinal, Radial and Tangential Shrinkage 2-3
Table 2.2 Shrinkage of Wood Species 2-9
Table 3.1 Material Air Permeability Rates 3-18
Table 3.2 Water Vapour Permeance of Common Materials 3-22
Table 4.1 Minimum Effective RSI Values for British Columbia's Coastal Zone 4-3
Table 4.2 British Columbia Building Code and Vancouver By-Law Nominal Insulation Values 4-4
Table 5.1 Performance Expectations for Exterior Wall and Window Moisture Control Strategies 5-3
Table 5.2 Effective Insulation Values 5-6
Table 5.3 Recommended Wall Assemblies for Exposure Categories 5-8
Table 5.4 Acceptable Window Assemblies for Exposure Categories 5-32
Table 6.1 List of Two-Dimensional Details 6-2
Table 7.1 Wood Product Selection Guide 7-2
Table 7.2 Typical Insulation Properties 7-4
Table 7.3 Comparison of Flashing Materials 7-9
Table 7.4 Comparison of Typical Cladding Types 7-14
Table 7.5 Comparison of Typical Exterior Wood Cladding Species 7-15
Table 7.6 Durability of Typical Exterior Coating Applications 7-16
Table 7.7 Recommended Minimum Window Performance Levels for the Coastal Climate Zone 7-20
Table 7.8 Recommended Minimum Window Performance Levels for High Exposure 7-21
Table 7.9 Number of Recommended Field Tests 7-23
Table 7.10 Comparison of Skylight Design Features 7-25
Table 7.11 Typical Sealant Usage Guide 7-31
Table 7.12 Comparison of Coating Binders 7-34
Table 7.13 Summary of Membrane Features 7-38
Table 7.14 Membrane Performance 7-39
Table 9.1 Sample Maintenance Plan 9-3
Table 9.2 Sample Initial Renewal Plan 9-5

LIST OF DETAILS

Detail 1	Foundation Wall at Slab	6-4
Detail 2	Base of Wall/Foundation	6-6
Detail 3	Base of Wall/Concrete Parking Deck	6-10
Detail 4	Rim Joist	6-14
Detail 5	Water Shedding Roof/Wall	6-18
Detail 6	Waterproof Membrane Roof/Wall	6-22
Detail 7	Cantilevered Floor	6-26
Detail 8	Exterior Corner	6-30
Detail 9	Interior Corner	6-34
Detail 10	Cladding Transition	6-38
Detail 11	Window Head	6-40
Detail 12	Window Jamb	6-44
Detail 13	Window Sill	6-48
Detail 14	Door Sill–Protected Membrane Pedestrian Surface	6-52
Detail 15	Door Sill–Exposed Membrane Pedestrian Surface	6-54
Detail 16	Accessible Door Sill–Protected Membrane Pedestrian Surface	6-56
Detail 17	Accessible Door Sill–Exposed Membrane Pedestrian Surface	6-58
Detail 18	Door Sill–Pedestrian Surface Roof	6-60
Detail 19	Wall–Pedestrian Surface	6-64
Detail 20	Exterior Edges–Pedestrian Surface	6-66
Detail 21	Railing Attachment at Wall	6-68
Detail 22	Exterior Element–Wall	6-70
Detail 23	Exterior Element–Column	6-72
Detail 24	Glass Block–Head	6-74
Detail 25	Glass Block–Jamb	6-76
Detail 26	Glass Block–Sill	6-78
Detail 27	Wall Exhaust Vent	6-80
Detail 28	Electrical Fixtures	6-82
Detail 29	Pipes	6-84

4-D BUILD DETAILS

Window Sill/Jamb	6-88
Window Head/Jamb	6-89
Door Sill	6-90
Saddle	6-91
Exhaust Vent	6-92
Exterior Stairwell	6-93

CHAPTER 1

INTRODUCTION

BACKGROUND

Excessive building envelope performance problems have been experienced in low-rise wood-frame residential buildings in the coastal climate of British Columbia since 1985. The problems appeared sometimes as moisture ingress and damage to interior finishes; however, the most alarming symptom has been the occurrence of extensive wood decay. The *Survey of Envelope Failures in the Coastal Climate of British Columbia* identified key aspects of the design, construction, operation and maintenance which lead to the problem. This document provides the construction industry with the basis and impetus to develop solutions to these performance problems. The production of this *Best Practice Guide* is one element of the response to the recommendations made in the *Survey*. Other initiatives funded by CMHC include *Quality by Design: a Quality Assurance Protocol for Wood-Frame Building Envelopes in British Columbia*.

Wood-frame construction systems in use today have evolved over a long period of time. Changes have been driven by the availability of materials, development of new building materials, the growth of the population, and the pressure to use labour, materials and energy more efficiently. While this evolution has accelerated rapidly in the last 20 years, the fundamental wood-frame structural system has remained unchanged for much longer.

Traditional construction using repetitive wood member systems (as opposed to post and beam systems) has been codified in various local and national building standards. The prescriptive requirements in the current *National Building Code of Canada* serve as a model for the *British Columbia Building Code*. These requirements apply to the use of wood construction for residential structures up to four storeys in height. They are also used for buildings of other occupancies, providing that they do not exceed certain height, size and hazard limitations. Wood construction has been widely used because it has a proven record of performance under a wide range of climates throughout North America, when it is used in an appropriate manner with attention to detailing and durability.

CLIMATE

There has been much speculation regarding the prevalence of recent envelope failures in British Columbia's coastal climate. Although the *Survey* identified the physical reasons, it is more difficult to determine how the industry collectively evolved to produce problem buildings. What is clear is that the coastal environment of British Columbia is intolerant of design and construction practices that result in the accumulation of moisture in wood-frame assemblies. The graphic on the cover (adapted from "*Wood Decay Hazard in Canada Based on Scheffer's Climate Index Formula*") illustrates the coastal climate area to which this Guide is directed. The figure is based on a "Climate Index," a function of both temperature and precipitation. The coastal climate zone may be further limited to areas where the Celsius degree days are less than 4,000. Colder mountain areas are not part of the coastal climate zone.

Climate governs several important parameters that have an impact on the performance of wood-frame envelopes:

- The frequency and intensity of wind-driven rain is a determining factor in the amount of water entering from outside.
- The difference between indoor and outdoor temperatures determines whether, how much, and where condensation of moisture can form inside the assembly.
- The combination of temperature, humidity and sunshine determines the rate and direction of vapour transfer and, therefore, the drying potential.
- Outdoor temperature determines the temperature of materials in the outer part of an assembly. Fungal decay of wood will not progress unless the temperature and the moisture content of the materials are within certain ranges.

British Columbia's coastal region has a maritime climate characterized by moderate temperatures and a high frequency of rain and wind-driven rain with little snow accumulation. As shown in Figure 1.1, there is a marked difference between inland climates in colder regions of Canada, and the

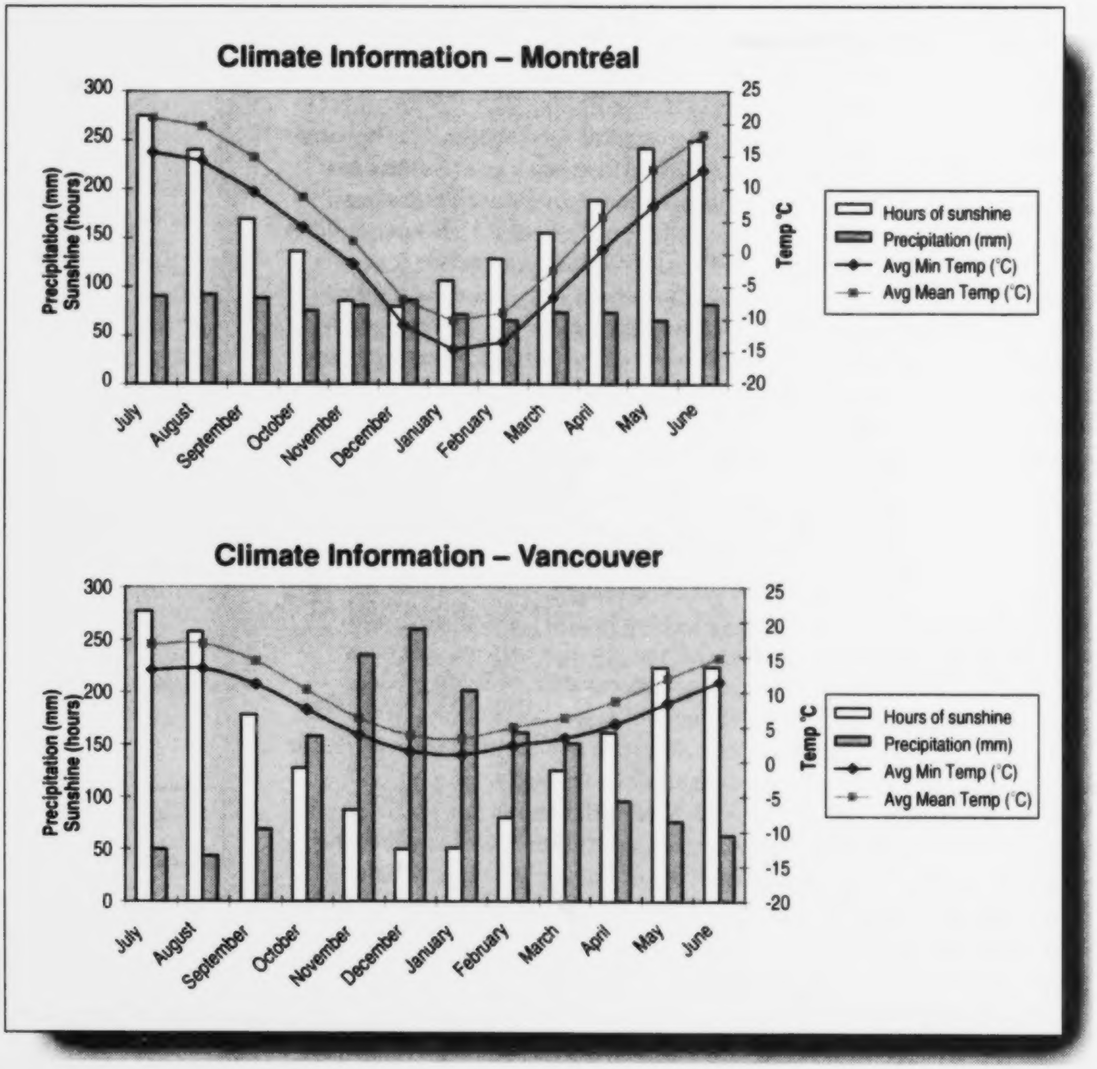

Figure 1.1: Comparison of coastal and inland climates

British Columbia coastal areas. For example, in the winter months Vancouver receives most of its rain and very little sun. **Wetting exposure of a building is high and drying potential is low.** The moderate temperatures reduce the potential for condensation from interior humidity but conversely allow fungal growth to occur even in winter.

The peak intensity of wind-driven rain in coastal British Columbia, measured by a factor called the Driving Rain Wind Pressure, is no greater than it is for some inland climates, but the frequency of wind-driven rain, as expressed by the Annual Driving Rain Index, is much higher. There is almost always a directional component to exposure to wind-driven rain. For most locations in the British Columbia coastal region, wind-driven rain tends to come from the east. However, this pattern can be greatly modified by local factors such as location and orientation relative to mountains, other buildings and bodies of water. Although wind-driven rain may occur more frequently from one direction, it is not generally advisable to design particular elevations of a building for differing exposure conditions, since it is probable that some wind-driven rain will occur on all building faces. The exception to this rule would be the high exposure conditions associated with an elevation oriented towards the ocean or other large bodies of water where additional protection or more moisture tolerant assemblies may be warranted.

This combination of climate factors dictates priorities for envelope design in British Columbia's coastal region:

- The most important wetting mechanism to control is rain penetration.
- There is little ability to dry materials by diffusion and venting, especially in winter, so that the ability to drain any water that gets past the cladding into the assembly is particularly important.
- Condensation from interior sources of moisture is a less important factor than it is for colder inland climates but should not be ignored.
- Insulation levels should always be determined based on a specific building analysis; however, the milder coastal climate zone will generally dictate lower insulation levels than in other regions of Canada.

THE BEST PRACTICE GUIDE

This Guide is intended to provide guidance, primarily to designers, for the design of the building envelopes of multi-unit wood-frame buildings in the coastal climate zone of British Columbia. The Guide should also be useful to the construction industry in general, encouraging an understanding of the behaviour and performance of building envelope assemblies. Much of the material in the Guide may also be applicable to other climate zones and building types. However, some analysis of the impact of the different climate factors and specific building attributes must be considered before the assemblies, details and materials presented in this Guide are utilized.

Although the Guide is intended to reflect good practice in general, its primary focus is on the management of moisture, since moisture-related performance problems prompted this initiative. The Guide therefore does not deal specifically with structural, acoustic or fire and safety issues that may also have an impact on the design of the building envelope. These performance criteria must be considered together with the moisture management criteria presented here.

The Guide is organized to take the user from a presentation of the unique British Columbia coastal climate environment, through an understanding of the behaviour of wood as a material and the fundamentals of moisture management, prior to presenting design guidance specific to best practice assemblies, details, components and materials. The two final chapters deal with Quality Assurance during the design and construction phases, and Maintenance and Renewal of the building envelope during its service life.

The Guide reflects current recommended best practice in design and construction. Best Practice in the context of this Guide means the balanced application of currently available technology, materials, and normal skilled workmanship to the design and construction of affordable and durable housing.

The Guide is not intended to be a research paper or an exploration of innovative technology. Although some of the proposed assemblies have limited field performance history in British Columbia, they are based on sound principles and are believed to be conservative for their intended uses. Most of the assemblies are being used successfully in Canada and in other parts of the world. As further research initiatives are undertaken, better understanding of performance of the assemblies may allow a less conservative approach in some circumstances. However, in the current environment of widespread envelope failures it is prudent to be cautious.

The Guide is not intended to replace professional advice. When this guidance is incorporated into buildings, it must be reviewed by knowledgeable building envelope professionals and reflect the specific unique conditions and design parameters of each building. Use of the Guide does not relieve designers of their responsibility to comply with local building codes, standards and by-laws with respect to the design and construction of the building envelope.

The Guide is not intended for use with taller buildings or those of non-combustible construction. The different materials and exposure conditions in these buildings often dictate quite different and more rigorous approaches to moisture management than are presented in this Guide. Furthermore, the Guide is not intended to be applied directly to the restoration of three- and four-storey wood-frame buildings. These projects require quite different detailing in many cases due to the fact that much of the building form and structure already exists and cannot be changed in a cost-effective manner.

An attempt has been made throughout the document to provide the user with direction to other useful reference material. In particular, the construction industry has historically been provided with good research and guidance on wood-frame design and construction practices from Canada Mortgage and Housing Corporation and the National Research Council of Canada through its Institute for Research in Construction. The following are the contact addresses and numbers for these two organizations. Their publication lists include many directly relevant documents.

Canada Mortgage and Housing Corporation
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National Research Council of Canada
Institute for Research in Construction
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Web site: www.nrc.ca/irc

KEY POINTS

- Wetting exposure of these coastal climate buildings is high and drying potential is low.
- The most important wetting mechanism to control is rain penetration.
- There is little ability to dry materials by diffusion and venting, especially in winter, so that the ability to drain any water that gets past the cladding into the assembly is particularly important.
- Condensation from interior sources of moisture is a less important factor than it is for colder inland climates but should not be ignored.
- Insulation levels should always be determined based on a specific building analysis; however, the milder coastal climate zone will generally dictate lower insulation levels than in other regions of Canada.
- The Guide is not intended to replace professional advice.
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MARGIN ICONS

Several Chapters in the Guide utilize icons in the margins to highlight and reinforce concepts presented. The following describes the purpose of the various icons.

Deflection

Indicates that this water management principle is discussed or illustrated in the adjacent text

Drainage

Indicates that this water management principle is discussed or illustrated in the adjacent text

Drying

Indicates that this water management principle is discussed or illustrated in the adjacent text

Durability

Indicates that this water management principle is discussed or illustrated in the adjacent text

Further Research

Indicates that an unresolved technical issue requiring further research is discussed in the adjacent text

Key Point

Indicates that an important recommendation or observation is made in the adjacent text.

These Key Points are collected at the end of each Chapter into one table.

Further Reading

Indicates that reference is made to a document or a source that could provide additional information with respect to the issues and information presented. These references are collected together and listed at the end of each Chapter along with selected other general reference material.

CHAPTER 2

BEHAVIOUR OF WOOD IN CONSTRUCTION

The very wet environment of the coastal climate area and the fact that wood is subject to decay requires that our building practices protect wood. This chapter discusses the unique properties of wood and its use in wall and roof assemblies to assist in understanding how to build decay-resistant buildings. While traditional residential wood-frame construction involved few variants on basic assemblies, the wide choice in materials, components and architectural styles now available makes it more important that we understand the behaviour and limitations of wood.

CHARACTERISTICS OF WOOD

To successfully use wood building materials, some basic knowledge is needed regarding the cellular structure of wood, how it holds and reacts to moisture, how it is processed and what factors may result in its deterioration.

Softwood lumber, the product of coniferous (needle bearing) trees is most often used for wood-frame construction in North America. The wood from coniferous trees is used because it is economical and plentiful, more easily worked, and has a higher strength-to-weight ratio than hardwood. It is also readily available in the lengths needed for construction. Engineered wood-based members are becoming available to fill the need for deeper and stiffer structural sections.

Softwood is comprised of tubular cells which are about 4 mm long and 0.04 mm thick. Most of the cells are vertically aligned. Each year, trees grow a new layer of cells called a growth ring. The density and other cellular characteristics, including growth rate, account for some of the differences in strength and stiffness of different species of wood parallel to and across the grain.

The cells of normal wood shrink and expand mainly across their width as they lose or gain moisture. See Figure 2.1.

MOISTURE CONTENT AND SHRINKAGE OF WOOD

Moisture is held in wood in the cell walls and the cell cavities. When timber is felled, it has a high moisture content and needs to be dried before it can be used in building construction. **Moisture content is the weight of water contained in wood, expressed as a percentage of the weight of oven-dry**

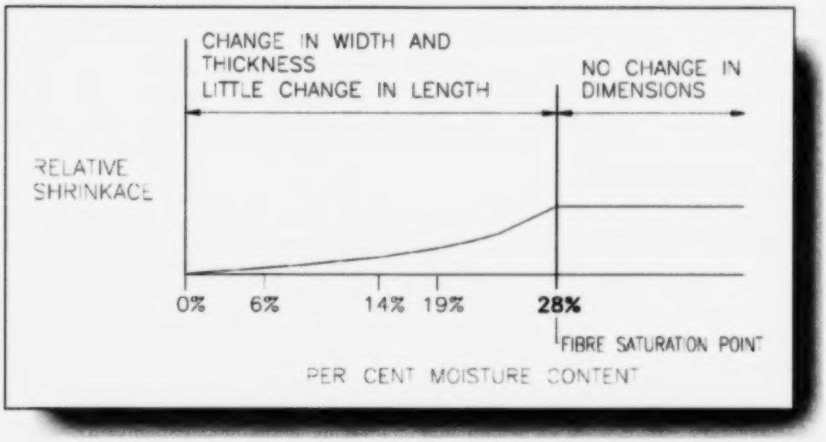


Figure 2.1: Wood shrinkage and moisture content

wood. The term 'oven-dry' indicates that there is no moisture in the cell fibres or the cell cavities.

As wood dries, the water leaves the cell cavity first. When the cell cavities are empty of water, the cell walls begin to dry out. The Fibre Saturation Point occurs when the cell walls are saturated but the cell cavities are empty; usually at about 28 per cent moisture content (Figure 2.2). Kiln drying involves the rapid removal of moisture by the use of high temperatures. The kiln drying process also helps arrest incipient decay, that is, decay that may have been present in the standing timber or that may have developed prior to sawing the lumber.

Expansion and contraction of wood occurs in relation to the amount of moisture contained in the cell walls; therefore dimensional change occurs only below the fibre saturation point.

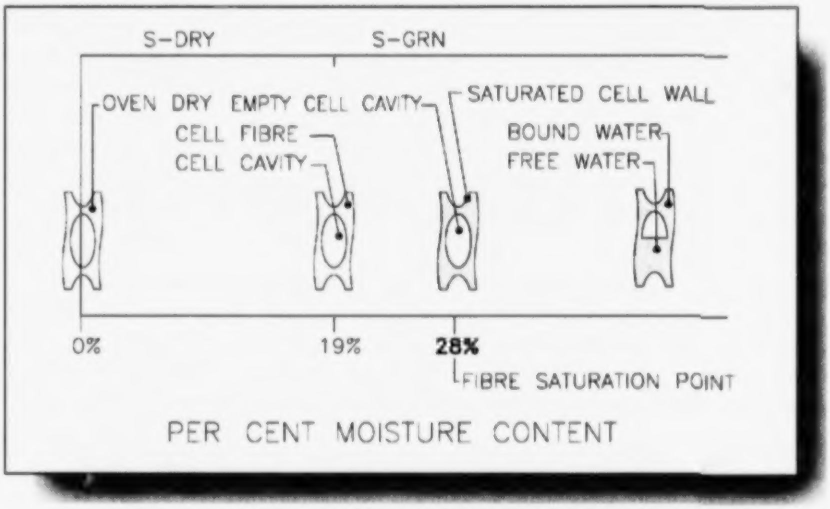


Figure 2.2: Fibre saturation point and wood cell structure

The behaviour of wood building materials after manufacture is closely related to fluctuations in moisture content within the wood. This has implications for the design of wood-frame structures and the performance of the building envelope.

The change in length of wood along the grain is small, except where grain irregularities occur or the lumber has been sawn at an angle to the grain. Shrinkage is also greatest in the circumference of a log (the tangential grain direction) compared to the radial grain direction. Table 2.1 provides the approximate average shrinkage for a single percentage change in moisture content in each orthogonal grain direction. For example, if the change in moisture content is 10 per cent and radial shrinkage is 0.17 per cent for each 1 per cent change in moisture content, the resulting radial shrinkage expected would be 1.7 per cent. Normally, a user has no control on ring orientation or species selection and a composite estimate for transverse grain shrinkage of 0.25 per cent per unit moisture content change should be used. Unlike other building materials such as plastic or steel, expansion and contraction of wood due to thermal conditions is relatively small and can be considered insignificant for construction purposes.

Natural grain irregularities, knots and variations between each piece of wood affect how each piece of lumber changes on drying. Heartwood usually has less moisture than the sapwood located at the perimeter of the tree under the

Table 2.1: *Longitudinal, Radial and Tangential* [illegible]

	Longitudinal	Radial	Tangential
per cent shrinkage per 1 per cent change in moisture content	0.005 per cent	0.11 per cent to 0.17 per cent	0.15 per cent to 0.30 per cent

bark. The cross-sectional shape of wood products after drying can sometimes be affected by the way it is cut from a log (see Figure 2.3).

Distortions in shape may also occur over the length of each piece of lumber (see Figure 2.4). Twisting, bowing, cupping and crookedness may occur to different degrees after drying. Lumber is graded for different applications in order to sort it into categories that represent different qualities. These limits are defined in the grading rules for each grade and species group.

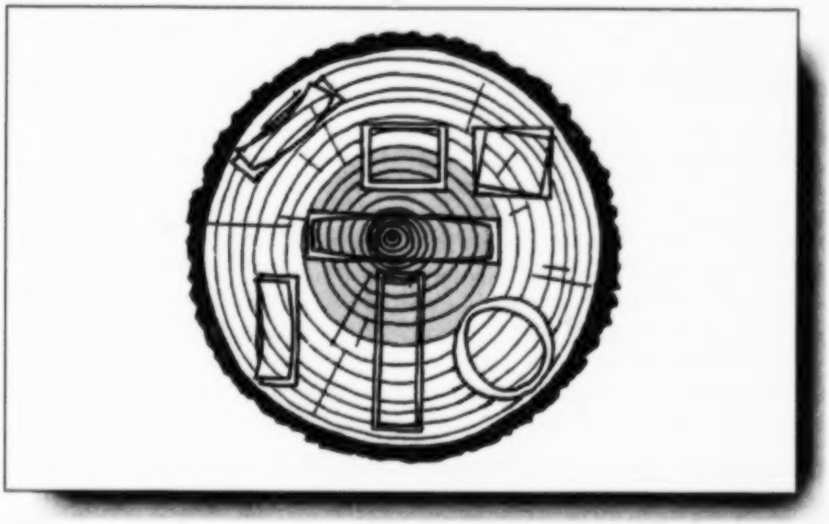


Figure 2.3: *Drying effects on cross-sectional shape*

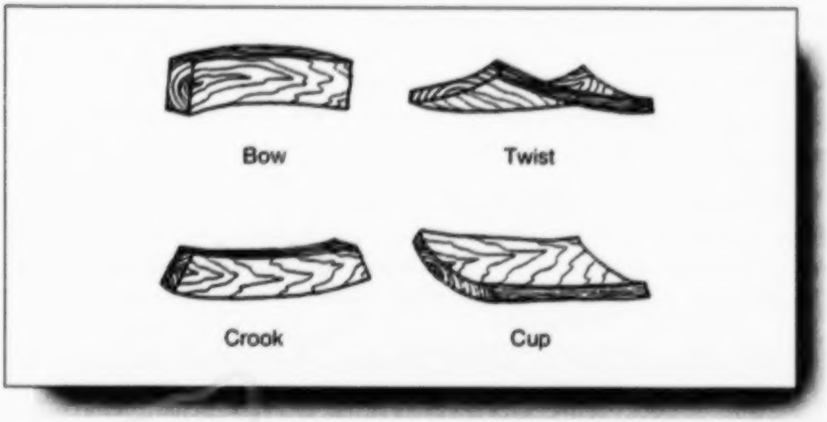


Figure 2.4: *Drying effects on lengthwise shape*

LUMBER PRODUCTION AND MOISTURE CONTENT

S-GRN and S-DRY are the lumber grading terms used to describe the moisture content of wood at the time of surfacing. Lumber is not graded until it has been planed smooth or surfaced. **S-DRY lumber has a moisture content of 19 per cent or less and is usually in the 15 to 19 per cent range.** S-GRN has a moisture content above 19 per cent and must be further seasoned prior to use. Some lumber manufacturers add the designation Kiln Dried (KD) to their products to designate their greater desirability. Nearly all S-DRY lumber is kiln-dried.

Since S-DRY lumber has been dried before surfacing, and a significant proportion of the total shrinkage has already taken place, the lumber will be more stable after incorporation in a building assembly. Also, S-DRY lumber tends to have higher-grade material since pieces that possess characteristics that lead to distortion will be easily identified by visual grading and be culled from the production line. Thus, S-DRY lumber that meets the moisture requirements is less likely to experience excessive:

- nail popping (in gypsum board)
- twisting
- differential movement
- air leakage when it is part of a wall assembly.

S-DRY or KD lumber must be protected against wetting by rain during shipment or storage at the building site.

S-GRN lumber, on the other hand, has not had an opportunity to show a predisposition for warping or bowing and the lumber grader cannot normally detect which piece will degrade. Thus, while S-GRN lumber (usually called "green") is quite straight at time of purchase, its dimensional stability cannot be ensured when it is incorporated into the structure. Indeed, the restraint provided by the rest of the floor, wall or roof assembly may be insufficient to hold every piece in line while the lumber dries, and remedial action may be required to replace distorted lumber in the structure after it has dried.

The moisture content of wood products will continue to change after installation in a structure. Wood cells will absorb or release moisture from their immediate environment until they reach a state of equilibrium with it. The Equilibrium Moisture Content depends on the relative humidity (Figure 2.5). Since this is always fluctuating, wood is constantly absorbing or desorbing moisture from the environment around it.

Factors that affect temperature and humidity conditions for wood at various locations in the structure include:

- natural seasonal variations in temperature and relative humidity
- location of the wood (interior or exterior)
- the wall orientation (north, east, south or west)
- shade conditions (heavy shade and shelter vs. open sunny location).

The wood will usually achieve a moisture content within the 8 to 14 per cent range after an initial drying stage which may last up to one year, depending on the climate and the localized drying conditions.

MOISTURE CONTENT – COMPOSITE WOOD PRODUCTS

Douglas Fir Plywood and Canadian Softwood Plywood are manufactured from rotary-cut veneers cross-laminated under heat and pressure. The adhesive used to bond the veneers is a liquid phenol formaldehyde applied by a glue spreader. Plywood produced in Canada for construction sheathing

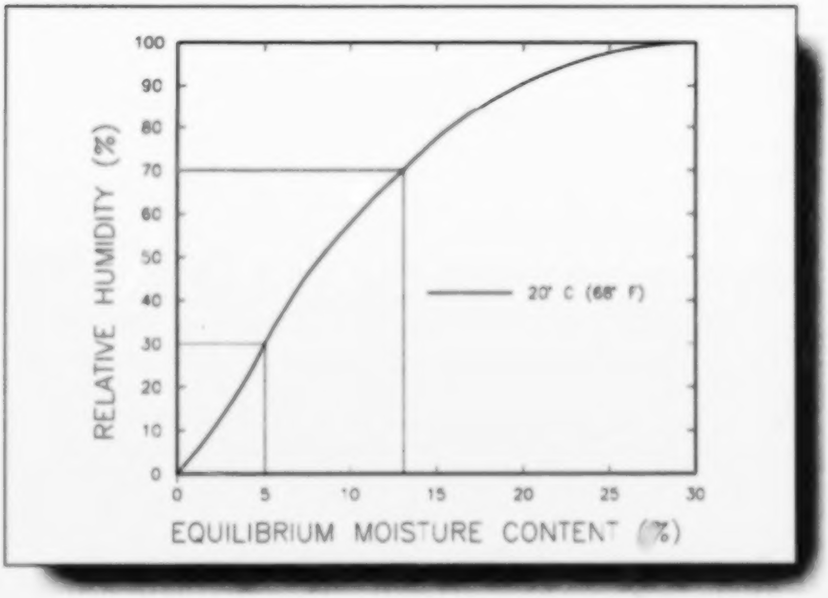


Figure 2.5: Relative humidity versus moisture content

in this way is considered to be exterior grade material. Under the same environmental conditions as solid wood, the equilibrium moisture content of plywood and OSB tends to be about 2 per cent lower than wood. The absorptive properties of plywood are somewhat lower than solid wood. If wetted on construction sites, it will absorb water fairly rapidly because of lathe checks in the veneers. The adhesive layers tend to inhibit moisture movement, but the adhesive spread is not a continuous film and both liquid water and vapour can pass through it. Some swelling of the product takes place on being wetted, but drying results in a near recovery of the original thickness.

Oriented strandboard is usually made of aspen strands or wafers bonded under heat and pressure. Pine or other hardwood species are also used. The face layers of the panels are oriented generally in the long direction of the panel, which increases its strength in that direction, while the core layers are oriented primarily across the face layers. The resin binder most commonly used in the past is powdered phenol formaldehyde. However, liquid phenol formaldehyde, isocyanate or a combination of these two are also being used. The strands are also sprayed with a wax system while blending with the adhesive to impart some water repellency to the finished product. Since the raw edges of oriented strandboard absorb moisture more readily than the faces, most oriented strandboard producers spray apply an edge coating consisting of an emulsion of wax and latex to control the rate of edge swelling. On long exposure to water, the absorption of liquid water leads to swelling of the strands and disruption of some of the adhesive bonds in OSB. The swelling of conventional oriented strandboard sheathing caused by a high intake of liquid water is largely non-recoverable. Dimensional stability is related to the quantity of moisture absorbed by a product. Even stable products can be affected adversely by significant amounts of water.

The wood veneers and strands used to make these and other composite wood products are dried to between 3 and 7 per cent moisture content prior to fabrication. While the panel edges are usually protected with a paint or sealer to slow absorption, panels need to be installed with a 3 mm space between them to allow for the expected expansion.

Since engineered wood I-joists are made using kiln dried lumber or composite lumber flanges, and plywood or oriented strandboard webs, they are relatively dry products and are more dimensionally stable than lumber under normal protected conditions. Bowing, warping or twisting distortions are seldom experienced. These products need to be protected from moisture during shipping and storage at the building site.

DECAY IN WOOD

Wood-frame structures have generally withstood the test of time in the British Columbia coastal climate and most of these structures have remained free of decay. **The most effective way to prevent decay is to keep the wood dry.** However, in certain conditions, decay will occur and can cause costly damage to the building structure. Knowing why it happens and how to avoid it are therefore important to envelope design. Decay, or rot, occurs due to the growth of specific fungi, which feed on cellulose fibres. Fungal spores are found throughout the environment and will grow on wood in the presence of:

- oxygen
- moisture, and
- warm temperatures.

Air is found throughout the cellular structure of wood, so oxygen is nearly always available. Spores of decay fungi will germinate at 25 to 28 per cent moisture content and flourish when the moisture content of wood is between 35 and 50 per cent. The spores will not germinate on wood that has a low moisture content. Other non-decay fungi can grow and flourish when the temperature is warm enough and relative humidity at the surface of the wood or other material is 85 per cent or higher. Decay fungi, once they have taken hold, may continue to grow at a sustained moisture content as low as 20 per cent. **At or below 19 per cent moisture content, wood is considered immune to fungal growth** (Figure 2.6). Building codes require that the moisture content of the lumber be no greater than 19 per cent at the time of installation in a building. Although there can be local wet pockets in the lumber, the 19 per cent moisture content limit results in satisfactory long-term performance under most conditions, because further drying is expected in an appropriately designed and constructed building envelope.

The temperature range for optimal fungal growth is 18°C to 35°C (65°F to 95°F). Above this range, the growth decreases and will cease at about 38°C (100°F). As the temperature falls, the growth slows. In cold temperatures, fungi become dormant but will be activated again when it gets warmer. **In the coastal climate zone, the temperature gradient through the wall assembly, combined with the relatively warm exterior winter temperatures, can result in conditions conducive to fungal growth throughout the winter if the moisture content requirements are also present.** If wood has been previously infected with decay fungi, and not subsequently kiln-dried the fungi can be revived from dormancy if moisture content increases to a suitable level.

When wood is kiln dried, the decay organisms are killed. If the wood is rewetted to sustained higher moisture levels, it can be re-infected in most environments. The use of kiln dried wood ensures that the likelihood of decay in the end product is far lower, unless defects in the envelope lead to the accumulation of moisture suitable for fungal growth.

The heartwood of some species of wood, such as western red cedar and Pacific Coast yellow cedar, contains naturally occurring chemicals, which

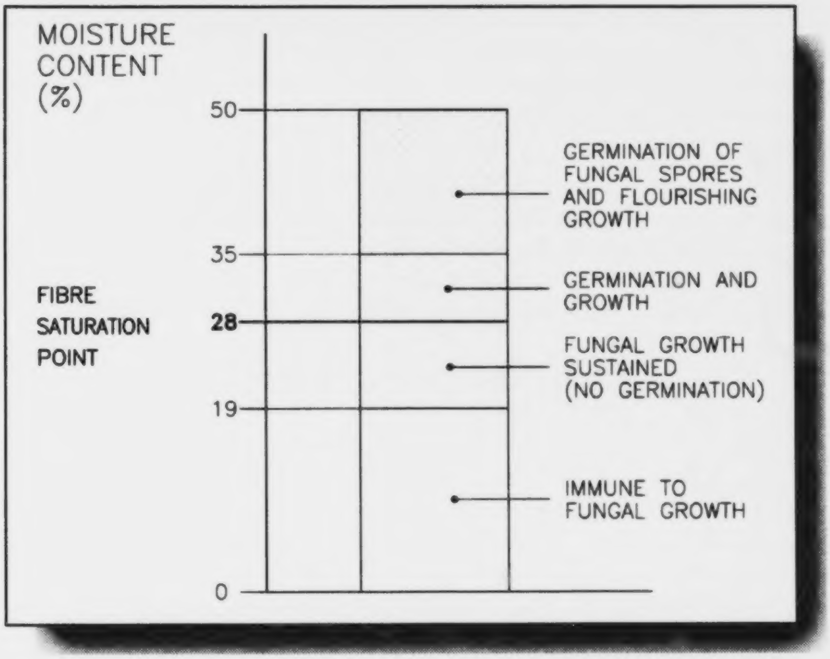


Figure 2.6: Fungal growth in wood

inhibit the growth of fungi and provide greater protection against decay. Western red cedar is classified as decay resistant, Douglas fir is moderately decay resistant, and the spruce-pine-fir group and hemlock are considered non-decay resistant. The sapwood of all of these species is not decay resistant and therefore cannot be used in high moisture conditions without the onset of early decay. However, lumber may be pressure treated with chemicals to suitable levels to prevent the growth of fungi or attack by insects. Western red cedar has relatively low strength properties so it is mainly used for non-structural applications such as shakes, shingles, siding and fascia boards.

MOISTURE TOLERANT WOOD: NATURALLY DECAY RESISTANT OR PRESSURE-TREATED

For interior applications, the use of moisture-tolerant or treated wood products should be unnecessary unless there is a reasonable expectation that the design, construction, building operation or maintenance/renovation processes will lead to a moisture content repeatedly above 25 per cent. For ground-contact exterior applications, non-decay resistant and moderately-decay resistant woods should always be pressure treated if they are to last more than a few years. For above-ground exterior applications, the decision to use naturally decay resistant or pressure treated wood is more complicated. It depends on the climate, the design, the degree of exposure, the design life, the maintenance/replacement requirements and the consequences of premature failure.

The climate region covered by this Guide is highly conducive to the decay of wood. While careful design can promote deflection and drainage of water from exterior wood elements, and small dimension lumber will dry out rapidly after rain, these three lines of defence (deflection, drainage and drying) may not be adequate. Rain can be trapped in joints, on horizontal surfaces or in cracks, and the end-grain of the wood readily absorbs this moisture. If wood is not protected from exposure to rain, including windblown rain and leaks, it can remain at a suitable moisture content long enough for decay to begin. Paint alone is not adequate protection under these circumstances. Paint or stain can be applied to wood that has been pressure treated with waterborne preservatives and will weather better than it does on untreated wood.

It is recommended that all inaccessible wood and structural elements outside the moisture barrier of the main environmental separator be pressure treated. Inaccessible refers to wood elements that cannot be reached without removing an outer cladding. Chapter 7 gives guidance about specific components to be pressure treated and pressure treating standards.

WOOD FRAMING ISSUES

Building Solutions: A Problem Solving Guide for Builders and Renovators provides guidance on a variety of technical problems related to wood-frame envelope construction. It also deals with a variety of other wood-frame and moisture issues that are not necessarily envelope related. Although this publication has a cold climate bias, it is also largely relevant to the coastal climate zone.

There are two wood framing issues which require further elaboration. They are nail popping and compatibility.

Nail Popping

Any shrinkage of wood along the length of an embedded fastener may cause its head to rise above the wood surface and its tip to penetrate slightly deeper. The result is that the nail head will rise above the surface of the gypsum board or sheathing which it secures. The result is unsightly, and could lead to a loss in airtightness in some layers in a wall assembly. The use of the shortest fasteners, annular nails or screws necessary to secure the gypsum board will reduce the incidence of nail popping.

Shrinkage also leads to the slight opening of gaps in the frame. Without the use of membrane materials, it is difficult to maintain the airtightness that is necessary for the energy efficiency of a structure. With special attention to detail and the use of caulking and gaskets, systems such as the airtight drywall approach (ADA, discussed in Chapter 3 and illustrated in Chapter 6) can overcome deficiencies related to shrinkage and nail popping.

Compatibility with Other Materials

Over time, framed lumber attains a lower moisture content than at the time of construction. It therefore shrinks during this period. Plywood and other engineered wood products generally have a lower moisture content at the time of manufacture, so they gain moisture initially.

When moisture content changes occur, differential movement will occur when wood is used in combination with other materials such as steel and masonry.

As described previously, shrinkage is expected in lumber across its width while longitudinal shrinkage is negligible. In a structure of several storeys, each of the wall plates and joists will contribute to an overall shrinkage which can be significant. Actual shrinkage varies between species. Refer to Table 2.2 for actual shrinkage values.

Table 2.2: Shrinkage of Wood Species

		Shrinkage (per cent) of Green Wood to:			
		19%	15%	12%	6%
RED CEDAR (WESTERN)	radial	0.9	1.2	1.4	1.9
	tangential	1.3	2.5	3.0	4.0
DOUGLAS FIR (COAST)	radial	1.8	2.4	2.9	3.8
	tangential	2.5	3.8	4.6	6.1
DOUGLAS FIR (INTERIOR)	radial	1.4	1.9	2.3	3.0
	tangential	2.5	3.4	4.1	5.5
HEMLOCK (WESTERN)	radial	1.5	2.1	2.5	3.4
	tangential	2.9	3.9	4.7	6.2
LARCH (WESTERN)	radial	1.7	2.2	2.7	3.6
	tangential	3.3	4.6	5.5	7.3
PINE (EASTERN WHITE)	radial	0.8	1.0	1.3	1.7
	tangential	2.2	3.0	3.7	4.9
PINE (RED)	radial	1.4	1.9	2.3	3.1
	tangential	2.6	3.6	4.3	5.8
PINE (WESTERN WHITE)	radial	1.5	2.0	2.5	3.3
	tangential	2.7	3.7	4.4	5.9
SPRUCE (EASTERN)	radial	1.5	2.0	2.4	3.2
	tangential	2.5	3.6	4.4	5.8
SPRUCE (ENGELMANN)	radial	1.4	1.9	2.3	3.1
	tangential	2.6	3.6	4.3	5.7

NOTES:

1. Tangential shrinkage applies to the width of the flat-grain face. Radial shrinkage applies to the width of the edge-grain face.
2. To calculate expected shrinkage, determine the average equilibrium moisture of wood for end use conditions.

In a three-storey structure frame with 235 mm spruce joists installed at 19 per cent moisture content, the overall shrinkage of joists and plates will be 15 to 20 mm when a moisture content of 10 per cent is reached. If the framing lumber was installed at 28 per cent moisture content, the overall shrinkage could be double this range (30 to 40 mm). This amount of movement can create severe problems for connections to plumbing stacks, elevator shafts and other services that are relatively rigid. Good design of these systems will ensure that movement can be accommodated.

Portions of the structure supported on masonry or steel will remain at a constant elevation relative to the portions supported solely on wood bearing walls. A floor that was level at the time of construction may slope significantly as a result. Some examples of problems that might result from differential drying shrinkage follow.

Example 1

Wood columns may be built into exterior or interior walls to carry the load of beams or other columns. The horizontal wood-frame members shrink, but the wood columns do not. Gaps open up in the wall joints (Figure 2.7). In a multi-storey construction, serious disruption can also occur in the floors and roof.

Recommendation: Support the loads using steel members that support the same amount of horizontal framing lumber (and same moisture content) as the rest of the structure so that the shrinkage and settlement under load is the same. Carry the loads through the floor assemblies or to supporting bearing walls using appropriate load transfer blocking so settlement under load is uniform.

Example 2

Multi-unit wood-frame residential buildings are often built with concrete block fire walls. If the exterior wood-frame walls are installed at 19 per cent moisture content and the adjoining walls reach a moisture content of 10 per cent, this may result in a cumulative shrinkage of 15 mm in the horizontal members (plates and joists). The gypsum board finish at the junction of the party wall and exterior wall may then separate (Figure 2.8).

Recommendations: Support the gypsum wall board at the fire wall on framing which is independent of the masonry, or provide a movement joint at the junction of the two assemblies.

Example 3

The apartment balconies in a four-storey apartment building are supported on steel columns. The wood structure shrinks 20 mm and the steel columns do not shrink. The balconies develop a back slope which allows water to run back into the building envelope (Figure 2.9).

Recommendations:

- Support the balconies on a wood structure which exhibits the same shrinkage as the wall structure or construct the balconies as an independent structure, or
- Provide sufficient slope in the wood balcony framing to ensure positive drainage even after shrinkage has occurred, or
- Design the length of steel columns to ensure positive drainage away from the building envelope after shrinkage has occurred.

Example 4

A four-storey wood-frame apartment building is clad on the lower three floors with brick veneer. A cap flashing covers the top of the brick. The wood structure shrinks 20 mm and distorts the brick cap flashing allowing water to flow into the wall (Figure 2.10).

Recommendation: Provide a flashing profile which allows movement between the brick veneer and the wood-frame without distorting the flashing.

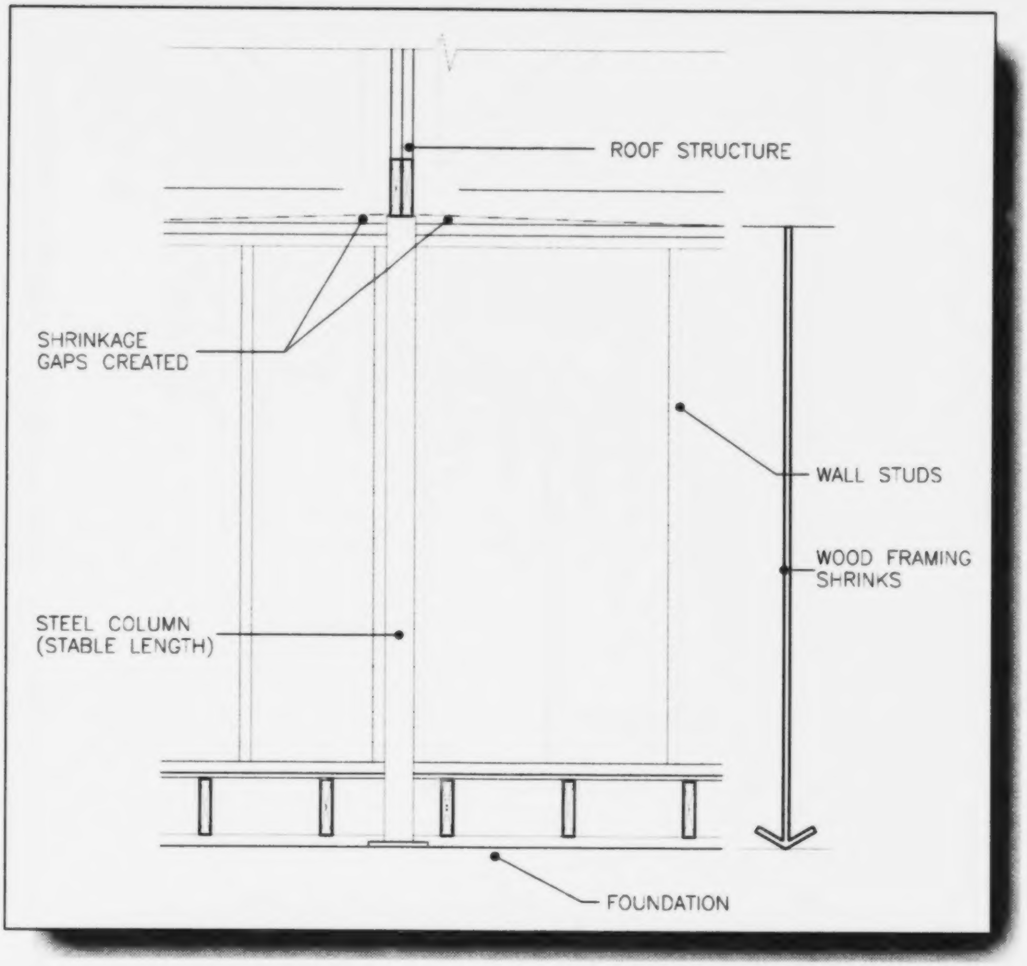

ROOF STRUCTURE
SHRINKAGE GAPS CREATED
WALL STUDS
WOOD FRAMING SHRINKS
STEEL COLUMN (STABLE LENGTH)
FOUNDATION

Figure 2.7: Shrinkage at steel column

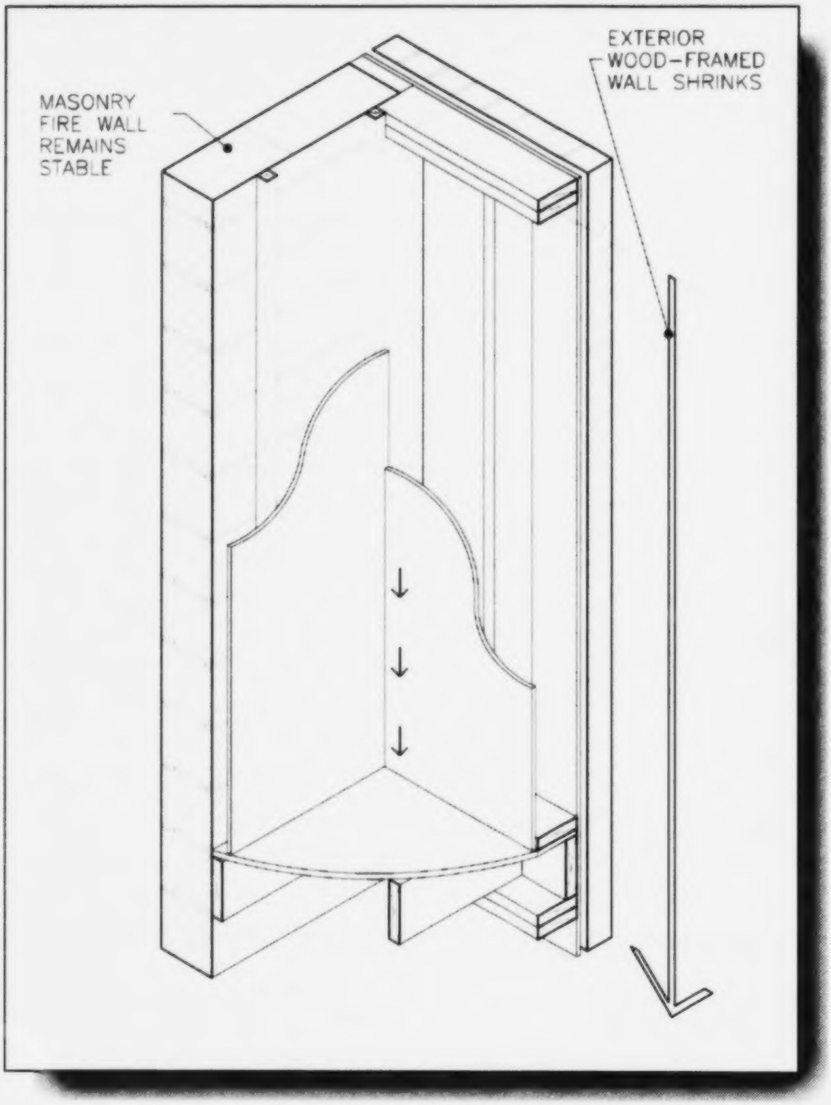

MASONRY FIRE WALL REMAINS STABLE
EXTERIOR WOOD-FRAMED WALL SHRINKS

Figure 2.8: Shrinkage at fire wall

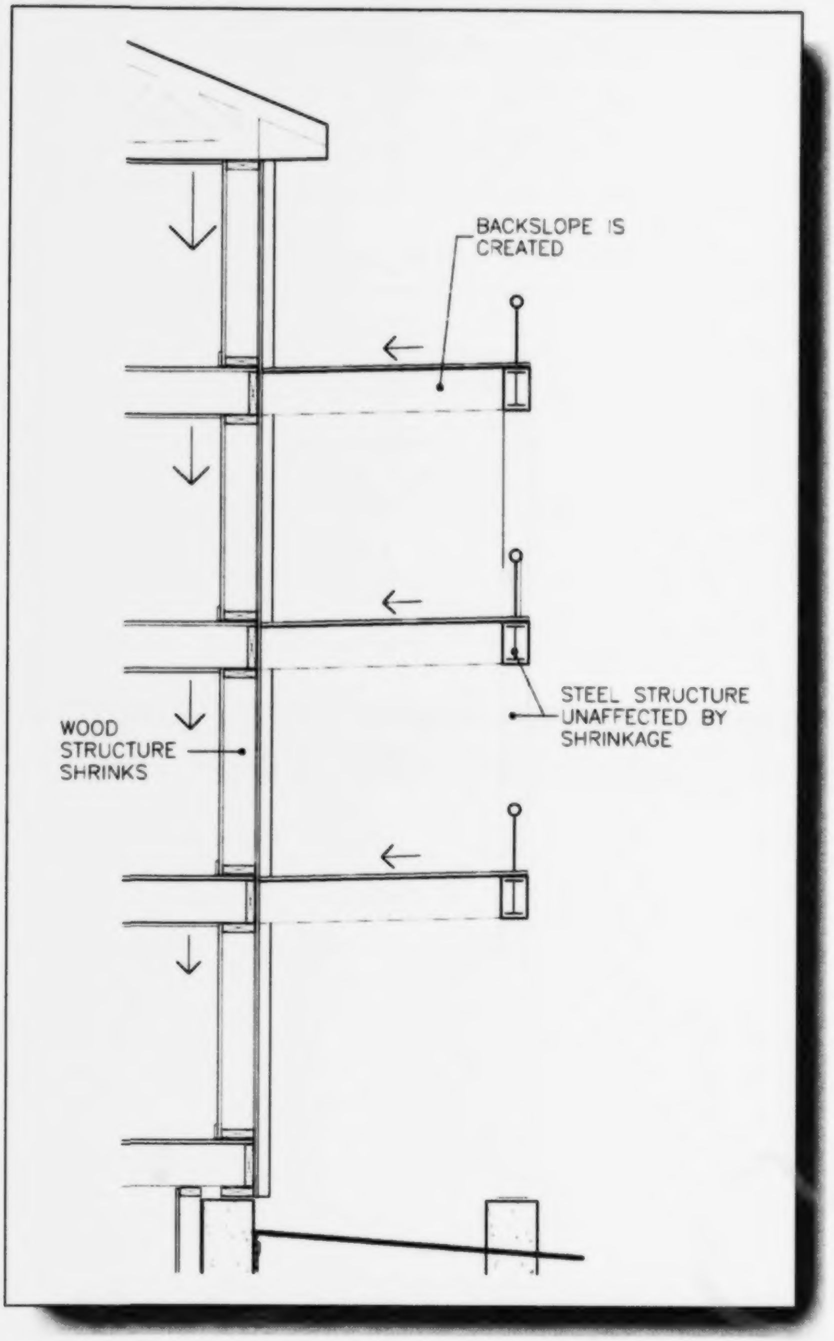

BACKSLOPE IS CREATED
STEEL STRUCTURE UNAFFECTED BY SHRINKAGE
WOOD STRUCTURE SHRINKS

Figure 2.9: Shrinkage at balconies

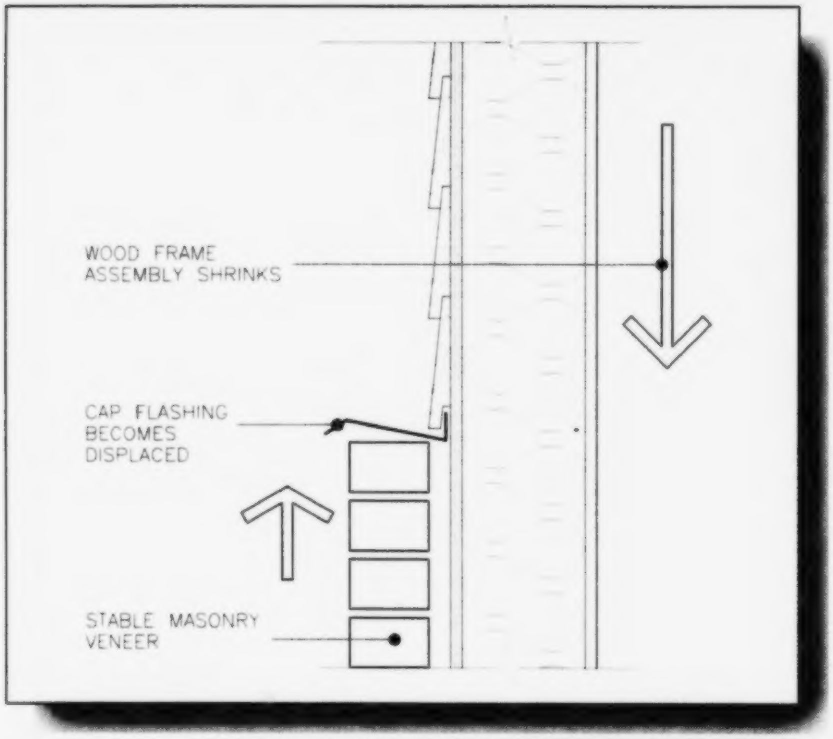

WOOD FRAME ASSEMBLY SHRINKS
CAP FLASHING BECOMES DISPLACED
STABLE MASONRY VENEER

Figure 2.10: Shrinkage at masonry veneer

KEY POINTS

- Moisture content is the weight of water contained in the wood, expressed as a percentage of the weight of oven-dry wood. The term 'oven-dry' indicates that there is no moisture in the cell fibres or the cell cavities.
- S-DRY lumber has a moisture content of 19 per cent or less and is usually in the 15 to 19 per cent range.
- The most effective way to prevent decay is to keep the wood dry.
- At or below 19 per cent moisture content, wood is considered immune to fungal growth.
- In the coastal climate zone, the temperature gradient through the wall assembly, combined with the relatively warm exterior winter temperatures can result in conditions conducive to fungal growth throughout the year if the moisture content requirements are also present.
- It is recommended that all inaccessible wood and structural elements outside the moisture barrier of the main environmental separator (envelope) be pressure treated.

CHAPTER 3

CONTROLLING MOISTURE SOURCES

MOISTURE BALANCE

Moisture needs to be controlled from many sources to ensure the durability of most building envelope assemblies. Moisture flow must be managed to prevent water retention and the elevation of moisture content of wood-based materials to levels conducive to fungal growth. Wetting and drying mechanisms require balancing to maintain the moisture content within the tolerance level of the materials.

Many building materials can be damaged by uncontrolled moisture. Interior finishes are subject to mold, mildew and deterioration in the presence of moisture. Masonry may spall if it remains wet and is subject to freeze-thaw cycles. Steel will corrode in the presence of air and moisture. Wood changes dimension and, more importantly, when exposed to sustained high moisture content in suitably warm conditions, it can decay.

As discussed in Chapter 2, wood and wood-based materials always contain some moisture; the amount varies over time with exposure to humidity and water. Fortunately, the equilibrium moisture content of wood exposed to humidity alone is still generally below that conducive to growth of decay fungi. There generally needs to be liquid water present from some source to lead to decay conditions.

The four Ds: Deflection–Drainage–Drying–Durability provide a ready reminder of the considerations and priorities for the design of a successful wall or roof, although they are perhaps an oversimplification of building science.

Deflection: Using components and features of the building to limit exposure of assemblies to rain. These include:

- overhangs which protect an assembly from direct exposure to rain
- flashing with drip edges which divert water running down surfaces and direct it off the face

Drainage: Using assemblies to redirect any liquid water that enters the system to drain back to the outside.

Drying: Providing features that speed the drying of wet materials.

Durability: Using assemblies and materials that are tolerant of moisture.

Deflection is the primary moisture control principle since it eliminates the potential for water to impact on or enter an envelope assembly. Drainage is the next most important principle. If a small amount of water enters the assembly, it must be redirected out. Any moisture that doesn't drain quickly must be able to dry. Since the drying mechanism is slower than deflection and drainage it should not be relied upon to the same extent. The surface upon which moisture rests must be durable enough to accommodate the moisture until it drains or dries.

WETTING MECHANISMS

Besides accidental sources of water such as pipe leaks, moisture can enter a building envelope from any of the following sources:

Exterior Moisture: Enters from the outside environment into a completed building. It has several forms, including (in decreasing order):

- rain penetration
- groundwater
- snow melt
- condensation of vapour from high outdoor humidity or wet materials driven by outdoor heat to a colder inside surface
- wind-driven snow.

Interior Moisture: Generated from inside by the use and occupancy, when moisture migrates, via air movement or vapour diffusion, to a surface cold enough to allow condensation. When the vapour touches colder surfaces within the envelope, condensation occurs.

Construction Moisture: Built into the structure by use of wet lumber or other building materials or by precipitation during construction.

DRYING MECHANISMS

Water in an envelope assembly can be removed by several mechanisms:

Drainage: Gravity will tend to draw water down. Elements like sloped flashings use gravity to divert and drain water to a safe disposal area, usually the outside. Drains that go through, but not into, inside space are common on flat roofs and some skylight systems.

Drying to outside: Moisture in an envelope assembly will move by diffusion and venting (air exchange between the envelope cavities and a dryer environment) to an atmosphere of lower vapour pressure. Vapour pressure is governed by relative humidity and temperature. In winter when a building is heated, the outdoor atmosphere usually has a lower vapour pressure than a wet building envelope assembly. Even under warmer conditions, this is usually true since the outdoor relative humidity is below 100 per cent. Drying to outside is restricted by use of materials on the outside of the assembly that have low permeability to vapour diffusion and air movement. Drying will also be restricted if the face of the assembly is wet. Recent experimental work (Envelope Drying Rates Experiment, conducted by Forintek Canada Corp.) indicated that the width of the drainage cavity as well as top and bottom venting arrangements also impact the drying rates of wall assemblies.

Drying to inside: Drying to the inside after construction is not a normal operating condition in new buildings since heated indoor environments drive moisture outward. Our building codes require placement of a material of low vapour permeability (vapour barrier) on the inside of the insulation, and the insulation is normally located within the stud space. Some less traditional assemblies are presented in Chapter 5 which will allow the stud wall assembly to dry to the interior because the insulation and vapour barrier are placed on the exterior side of the wall or roof sheathing. In addition, the ability to dry out construction moisture to the inside before closing the assembly may be important.

EXTERIOR SOURCES

Three conditions are required to move water through a surface:

- **a source of water at the surface of the material**
- **openings through which it can pass**
- **a force to move the water through the openings.**

The elimination of any one of these three conditions will prevent water entry.

Sources

Limiting exposure to water is a valuable technique for reducing the magnitude, frequency and duration of moisture entry into an envelope assembly. Rain creates two types of exposure:

- **Direct impact** occurs as raindrops hit the surface. On vertical surfaces like a wall, this requires wind to provide a horizontal component to the raindrop path. Direct impact will, therefore, affect the windward face and, because of the air flow pattern around the building, be most intense at the edges (corners and roof).
- **Run-off** is another type of exposure. Some water can be absorbed in the surface materials, but most of the water will run down the surface under the influence of gravity. The volume of this run-off water increases with the height of the building. It should be noted that its path is not necessarily straight down. Wind can push the water sideways, and upward near the top of the building. To a lesser extent, capillary action can also move water laterally against the force of gravity.

Architectural features such as eaves and overhangs protect the walls below from both direct rain impact and water running from surfaces above. Use of features such as eavestroughs and flashing with drips can deflect run-off water away from the exterior wall surface.

The *Survey* showed that using features that control water sources by deflection pays enormous benefits in a coastal climate. If most of the water is diverted before it impacts on the wall, then the requirements for drainage and drying mechanisms are significantly reduced. Figure 3.1 shows the relationship between the frequency of problems and the width of the overhang.

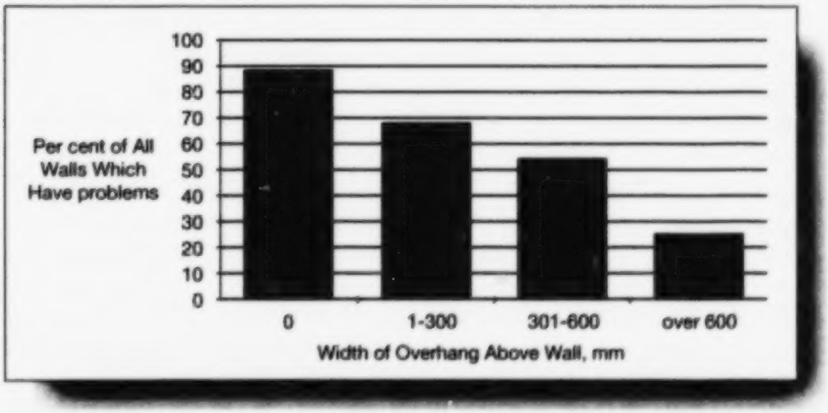


Figure 3.1: Effect of overhang on wall performance

(Reproduced from *Survey of Envelope Failures in the Coastal Climate of British Columbia*)

Openings

The use of material combinations that are waterproof is required to eliminate openings. Most importantly, however, joints and interface details that are waterproof and durable are needed. This requirement for durability separates acceptable assemblies and details from those that are not successful. Elimination of openings as the sole means of controlling exterior sources of moisture is very difficult to achieve. Most successful designs combine the elimination of most openings with other control strategies.

Forces

There are four main forces which can drive water leakage:

- Kinetic energy or raindrop momentum: Wind-driven raindrops can have a significant horizontal velocity. Near the top of the building, there is an upward component. The raindrops' momentum can carry them directly through openings of sufficient size. Intentional openings, such as drains and vents, can be protected from direct entry of rain by cover battens, splines or internal baffles.
- Gravity: The force of gravity will cause water to move down the wall face and into any downward-sloped passages. Thus, drainage elements are typically designed to slope downwards toward the exterior. However, unintentional cracks or openings are more difficult to control. The provision of a cavity directly behind the cladding will allow any water penetrating past the cladding to be directed downward by gravity on the inside face of the exterior cladding. At the bottom of the cavity, the water can then be drained back to the outside through the use of flashing and weepholes.
- Capillary action and surface tension: Surface tension draws water into small gaps and fissures in a material until the material reaches saturation. If these gaps extend from the exterior to the interior, water is drawn through the wall. Capillary transfer is characteristic of porous cladding materials, but the introduction of an air space or cavity behind the cladding can break the capillary movement of water through the wall.
- Pressure differentials: An air pressure difference across the wall of a building can be created by wind, stack effect, or mechanical ventilation. If the pressure on the exterior face of the wall is higher than on the interior of the wall, water can be forced through leakage paths in the wall, even those having a limited upward slope. Air movement driven by pressure differences can also carry droplets directly through larger openings. From the perspective of water penetration control, pressures created by strong winds are of the most concern because they are generally of much higher magnitude than those caused by stack effect or mechanical systems.

In some cases, only one or two of these forces may be present, but in a windy rainstorm all of them will likely be acting to move the water through any available opening. Each must be addressed in the design of the envelope.

RAIN PENETRATION CONTROL

It is not usually practical to eliminate all exposure to water. Therefore control of water entry is achieved by eliminating holes (waterproofing) or by controlling the driving forces.

The most successful approach depends on the assembly and application in question. For roofs, we usually rely on waterproofing membranes, but also minimize hydrostatic pressure (caused by gravity) by providing slopes and drains. Below grade, the provision of drainage to control hydrostatic pressure is essential and waterproofing or damp-proofing is employed as a second line of defense.

Two basic strategies for stopping rain penetration through the cladding of wood-frame walls are discussed here: face seal and rainscreen. Face seal systems rely on eliminating holes through the cladding, and rainscreen systems incorporate both a drained cavity behind the cladding and an air barrier within the wood-frame portion of the wall assembly behind the cladding. Rainscreen assemblies rely more on managing the air pressure differentials which drive moisture into the wall assemblies than on eliminating holes in the cladding. Other strategies, such as concealed barriers and combinations of face seal and rainscreen, are possible.

If the first strategy (using a face seal) is employed, it is necessary to eliminate all leakage paths through the outer cladding. **Assemblies using a face seal strategy have proven to be unreliable because installing and maintaining perfect and durable seals at all joints and intersections between assemblies is very difficult.** Even if the problem of job site inaccuracies and imperfect workmanship can be overcome and a perfect seal can be achieved, the materials used to seal all openings are exposed to extremes of weather and to movements of the building. These stresses will eventually cause the deterioration and failure of the seals, creating openings through which water can pass. Unfortunately, these openings can be small and difficult to identify. Even a diligent maintenance program may not keep the building free of openings. Virtually all studies show that defective or **failed joints and penetrations are the primary entry path for exterior water entry into wall assemblies.**

In addition, the lack of drainage or venting of the face seal assemblies to the outside, combined with the use of finishes with moderate or low vapour permeability limits the ability of these assemblies to dry. This makes these assemblies very sensitive to moisture. Water that does get in can remain for long periods of time.

The presence of a drained cavity in the rainscreen strategy provides enormous benefit. Holes in the inner and outer surface are generally not aligned so that direct rain passage by momentum is eliminated. Water that passes through the outer surface (the rainscreen) is driven either by gravity, capillary action or air pressure differences. It tends to run down the back side of the cladding where it can be intercepted and drained back to the outside by flashing and weep holes. The combination of a wall cavity and vent paths to the outside improves the drying capability of the assembly. These features mean that the amount of water reaching the inner surface of the cavity and remaining in contact with moisture-sensitive materials is greatly reduced.

There are two schools of thought regarding the venting of cavities at the top of walls or at the level of the cross-cavity flashings. Venting the cavity will increase the volume of air that passes through the cavity and hence will increase the potential to dry moisture from the cavity. However, venting at the top of the cavity, particularly at the top of a building, may under some circumstances result in a negative pressure in the cavity which will tend to draw water into the cavity, or alternately wind-driven rain may enter through its own momentum. In general, the Guide has adopted the philosophy that eliminating the potential for water to enter the wall from exterior moisture sources is more important than drying potential and therefore the cavities shown in the details in Chapter 6 are not vented at the tops of walls.

Effective rainscreen performance in walls which incorporate cavities involves the ability to minimize the pressure differentials between the cavity and the exterior. **The provision of an effective air barrier within the stud wall assembly together with some compartmentalization of the cavity are the most critical aspects of managing air pressure differentials and thus rainscreen performance.** Vent area is another variable; generally the greater the vent area, the quicker pressure equalization occurs.

The introduction of a cavity to the assembly does not eliminate the need to address exposure by deflection or the need to limit major water entry paths. The enhanced ability to drain and dry increases tolerance to minor sources of moisture but it can be overwhelmed. In addition, **the use of a less sensitive wall assembly does not eliminate the need for good details and construction practice.** The *Survey* identified 17 different details that were found to be sources of water entry and the majority of these are addressed in Chapter 6.

Pressure Equalization Theory

In walls with a cavity, a further performance improvement can be gained by limiting the air pressure difference across the cladding caused by the wind. It is possible to design a rainscreen wall so that the pressure difference across the exterior cladding is close to zero. This requires three things:

- negligible air flow through the inner surface (that is, the inner wall must contain the air barrier system),
- the air space between the cladding and the inner wall must be vented to the outside (that is, it must be much less tight than the inner surface) so that air can flow quickly into the cavity,
- the cavity must be compartmentalized so that the air cannot flow laterally through the cavity from a high pressure region to a low pressure region.

When wind blows on the building facade, a pressure difference would normally be created across the cladding. However, if the cavity is vented to the outside and air is stopped from going though the inner air barrier or laterally, air will enter the vents until the pressure in the cavity and the outside pressure are the same. Note that the pressure that the wind applies to the wall is then carried by the inner layer which includes the air barrier, so it must be capable of withstanding the full wind loads.

Dividing the cavity laterally into compartments is required because the action of wind flowing around a building creates pressures and suctions distributed over the entire surface of the building. Figure 3.2 shows how average wind pressures vary around a building. In fact, pressure variations are much more complex than this because winds are not steady in either speed or direction. The pressure may be fairly uniform near the centre of the walls but steep gradients develop towards the corners and the roof line. At corners, there can be a strong positive pressure on one side and a strong negative pressure on the other side. This spatial variation in pressure will cause lateral air flow within the cavity unless it is interrupted at suitable intervals. In order to provide some control, compartmentalization seals should be installed at corners and parapets to isolate each face from the dramatic difference in pressure between adjacent faces. The discussion and figures on the following pages illustrate these points.

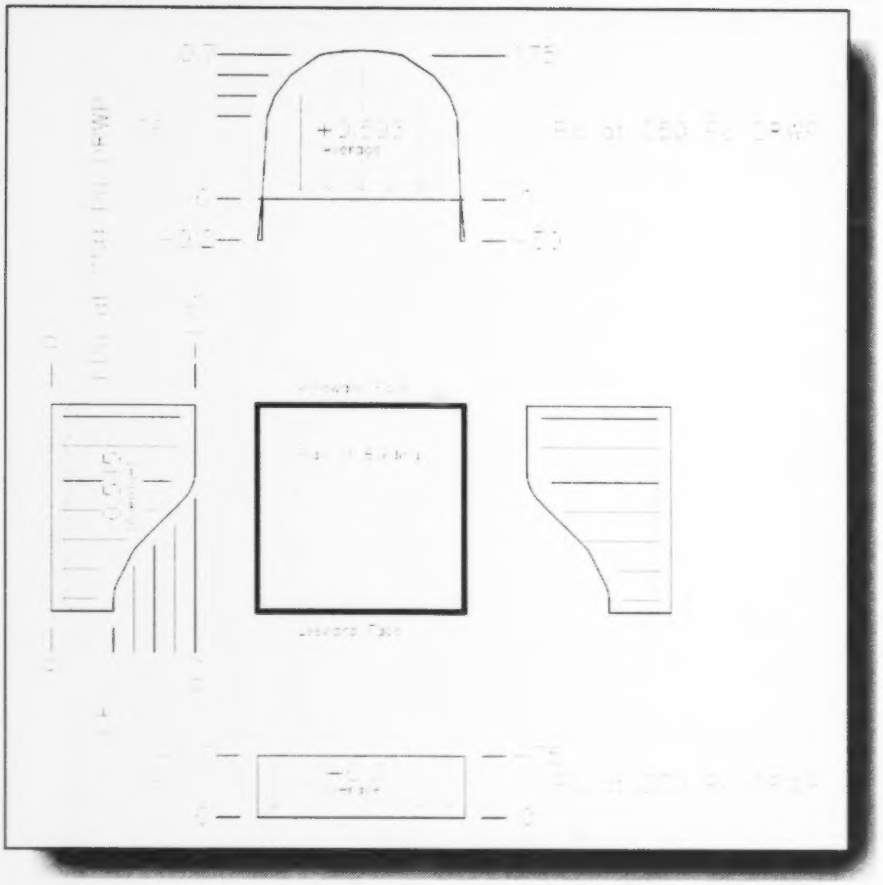


Figure 3.2: Wind pressures on buildings

The Importance of Compartmentalization at Corners

Figure 3.2 shows a plan of a square building with the wind normal to one face. For this discussion, we have scaled the pressure graphs to a wind pressure of 250 Pa, (which is higher than Vancouver's 1 in 5 year Driving Rain Wind Pressure). In the centre of the windward face, the pressure on the building wall acts inward and is about 175 Pa (pressure coefficient Cp = 0.7). This tails off rapidly near the corner, and, in fact, acts outward at the corner. At the sides and leeward face, the pressure acts outward.

No Compartmentalization

If a rainscreen wall assembly is used (where the inner wall is much more airtight than the rainscreen) with a wide open cavity all around the building, the pressure in the cavity would be an area-weighted average of the pressures around the building. In our example this is -50 Pa. The pressure difference across the rainscreen, as shown in Figure 3.3, is the difference between the wind pressure and cavity pressure at that point.

Note that the inward pressure at the centre of the windward face is now about 225 Pa. This high pressure can drive moisture though openings in the rainscreen and drive air flow and entrained water from the centre, to and around the corner.

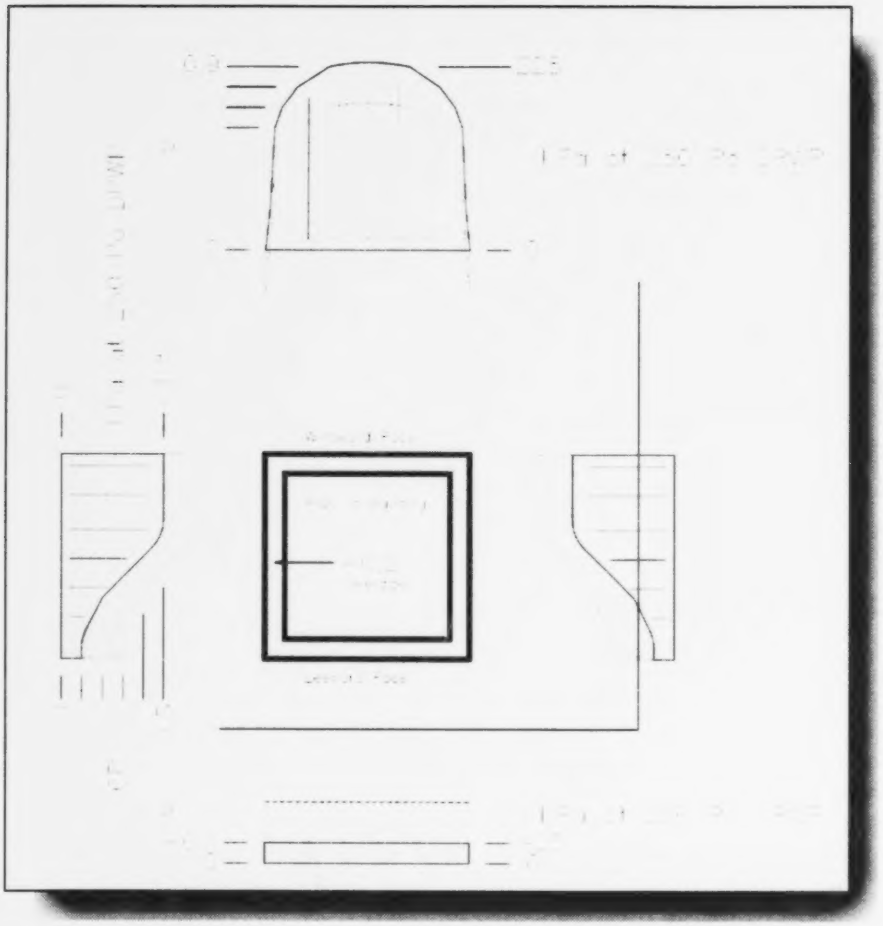


Figure 3.3: Pressure difference–No compartmentalization

Effect of Sealing the Corners
If each facade is isolated by sealing at the corners, the pressure relationships are dramatically changed (see Figure 3.4). On the windward facade, the cavity pressure would be about 150 Pa, and on a side facade about -135 Pa. The pressures available to drive water though the rainscreen and to create air flow in the cavity are greatly reduced. The peak inward pressure is about 25 Pa, or about 11 per cent of that without sealing at corners. Note also that the pressure difference across the corner seal is 285 Pa, which is higher than the total wind pressure the scale was based on.

Two design principles come out of this analysis:

- **Isolating facades by sealing the corners of cavities dramatically reduces driving pressures across the rainscreen, reducing the potential for and magnitude of water entry.**
- **Corner seals in cavities must be strong. They should be designed to withstand twice the structural wind load.**

In low-rise buildings, compartmentalizing at corners and at the roofline is usually adequate. In larger or higher exposure buildings, the cavity can be compartmentalized into smaller spaces, both horizontally and vertically. Compartment seals must be tight enough to prevent air leakage and strong enough to resist the wind pressure. At corners, this pressure differential can be twice the stagnation wind pressure.

To deal with the changes in pressure due to wind gusts (the cyclic pressures), the size of vents must be based on the working volume of each pressurization chamber, as well as the leakiness of the internal air barrier and compartment seals. In a high volume pressurization chamber, more air must move through the vents to achieve pressure equalization. The stiffness of the internal air barrier and the rainscreen must also be considered because this affects the working volume of the chamber.

Whether or not a cavity wall is pressure equalized, some water can enter the cavity from the exterior. The materials in the cavity and the face of the inner wall must be designed to accommodate this water entry. This generally requires that there be a second line of defense against moisture penetration located at the outer face of the inner wall. This is usually not the air barrier but is made up of water-resistant material, often building paper, lapped to shed water towards the base of the cavity. Flashing and drainage paths to the outside at the base of cavities to intercept water and direct it to the outside are an integral part of a successful rainscreen design.

Application of Rainscreen Principles

The rainscreen approach can be applied to most types of claddings used on wood-frame buildings to some degree. In any application, the following components must be present:

- a continuous air barrier system,

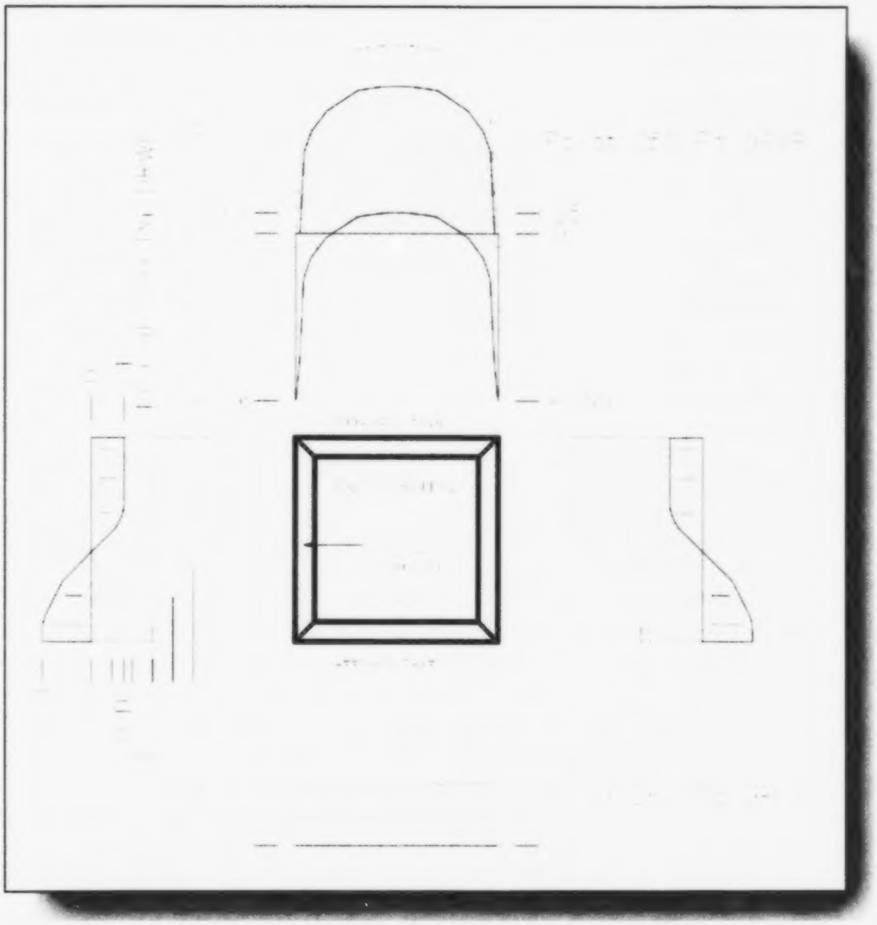


Figure 3.4: Pressure difference–Corner compartment

- an air space ventilated to the outside,
- a moisture barrier such as building paper or housewrap on the exterior face of the wall sheathing,
- drain holes or gaps so the water can leave the cavity, with flashing at wall base, doors and windows, etc., to direct the water to the outside,
- a compartmentalized cavity, achieved by blocking at corners, roof, and sometimes intermediate points (for pressure equalized rainscreens).

The following is a discussion of how these components can be applied to common cladding systems. In all cases, the backup wall must incorporate an effective air barrier system and a moisture barrier.

Masonry Veneer Cladding

Most masonry veneer walls use rainscreen principles because they incorporate the key elements of an air space between the cladding and the back-up wall, ventilation and drainage of the cavity to the outside through weep holes, and flashing at wall openings and at the wall base to direct water to the outside. To provide significant pressure equalization, it is also necessary to compartmentalize the cavity at building corners and, perhaps, at intermediate points.

Factors that can lead to water entry problems in masonry veneer include:

- blockage of drainage and vent paths by mortar droppings,
- leakage through and at the ends of base flashing because it is difficult to provide a slope at the brick bearing surface and at end dams,
- water getting across the cavity by running down back sloped masonry ties.

Vinyl and Aluminum Siding

Most vinyl and aluminum sidings are hollow-backed and naturally create a cavity when applied over sheathing. The nature of this cavity is not ideal, however. The cavity is not vertically oriented and can retain water against the sheathing paper at each horizontal bearing line. Alternatively, these sidings can be applied over strapping to create a more effective rainscreen cavity. Careful consideration may be given to alternatives to vertical strapping such as the use of an aluminium clip fit into the vinyl siding. This results in the vinyl being held out from the sheathing and creates a vertically oriented cavity. For pressure- equalized rainscreens solid blocking is still required at key locations to achieve a compartmentalized cavity.

The overlapping nature of the siding discourages the flow of water into the cavity. Any water that does enter should drain out through the integral ventilation/drain holes found in the lower edge of the siding profile. If the siding is strapped, water can also drain down and out at cross-cavity flashing locations. At interior and exterior corners, the use of corner trims and blocking can be detailed to create effective compartment seals.

In the *Survey*, walls clad with these types of sidings appeared to have a lower incidence of moisture problems than some others, but they still have problems. These types of claddings inherently have more joints in their assembly and therefore more details which potentially could allow water past the cladding. It is therefore still important to detail the walls to limit exposure by deflection and properly detail penetrations to minimize water entry into the wall.

For further discussion on issues related to the installation of vinyl and aluminum siding, see *Building Solutions: A Problem Solving Guide for Builders and Renovators*.

Wood Siding

Lapped wood siding systems create a cavity of limited and varying depth between the siding and sheathing (which must be protected by a moisture barrier). Many of the wood siding profiles used in British Columbia are either not lapped or are of a profile that does not create a significant cavity. It is therefore necessary to install the siding on strapping to create an adequate cavity. Strapped installation is advisable for lapped products as well, because it creates a vertically oriented cavity of a depth that limits capillary retention of water. Corner trim should be used to block the cavity at corners. Lapped wood and hardboard siding should be installed using round-headed siding nails, to maintain a gap between successive boards allowing ventilation and minimizing capillarity. Care must be taken not to overdrive the heads of the nails. The base of the wall should be detailed to allow drainage to the exterior (with flashing if necessary). Also refer to *Siding Problems*, published by CMHC as part of the Builder's Series.

Cement Stucco

Most of the conventional stucco wall assemblies constructed in the 1985 to 1997 period can be defined as face sealed assemblies or alternately as concealed barrier assemblies. The stucco finish can be quite porous (unless an acrylic or elastomeric coating is used), but behind the stucco there is a water-resistant layer such as sheathing paper. The water-resistant layer should include a flashing at the base of the wall to redirect any water that penetrates to the outside. The continuity and drainage capability of this inner water-resistant layer determines whether the wall is considered a face seal or a concealed barrier assembly. Whether these systems actually drain is debatable, and probably dependent on how the stucco was applied. In older stucco systems, in which tight mesh or wooden lath was installed in a furred-out position, a series of small, interconnected cavities can form between the stucco and sheathing paper, allowing some drainage. With welded wire lath and the stucco forced fully against the sheathing paper, there are no such gaps and capillary forces will restrict drainage.

Face seal and concealed barrier stucco wall assemblies work well in many dryer climates or where walls are sheltered by overhangs, but recent history has shown a high frequency of moisture problems with both types of conventional stucco wall assemblies in British Columbia's coastal climate. Many of these problems can be related to retention of water which enters at penetrations and joints with adjacent assemblies rather than through the stucco itself. This suggests that the limited capability for water to be removed by drainage and drying is an important factor which limits the reliability of these assemblies in exposed locations.

The appendix to the City of Vancouver's 1999 Building By-Law states that the intent of Section 5.6 of the By-Law is to require rainscreen wall assemblies as the minimum acceptable assemblies in most situations. This would mean that many traditional face seal or concealed barrier stucco walls are not acceptable in Vancouver. Stucco rainscreen walls can be created by installing the stucco on strapping to form a cavity behind it. Sheathing paper is installed between the sheathing and strapping, providing the required moisture barrier as well as flashing with drainage openings at the base of the cavity. The rainscreen cladding is provided by the combination of stucco, lath and sheathing paper.

Some alternate methods of providing drainage, including the use of foundation drainage materials, are currently being evaluated.

The Stucco Resource Guide published by the British Columbia Wall and Ceiling Association also provides guidance on design and construction of stucco wall assemblies.

Exterior Insulation Finish Systems

The use of exterior insulation finish systems (EIFS) on wood-frame buildings is relatively rare in British Columbia, since the benefits that they provide to wood-frame construction are limited. Conventional exterior insulation finish systems are face seal systems with the disadvantages associated with this water management strategy. Most proprietary exterior insulation finish systems manufacturers have now introduced drainage and pressure equalization strategies into some of their assemblies. Some of these assemblies are now being used successfully in wood-frame buildings in the United States, and in climate zones which are similar to the coastal climate of British Columbia. These assemblies are currently being proposed for use here and do have some inherent advantages since most or all of the insulation is placed to the exterior of the sheathing and there is no need for the polyethylene vapour barrier.

GROUND WATER

Moisture can migrate through foundation walls and basement slabs to the building interior. Every effort must be made to eliminate the potential for developing hydrostatic pressure. Effective footing drains are the primary defense against ground water. Where hydrostatic pressure may develop in the soil, it is necessary to waterproof the foundation and slab. In less adverse conditions, it is still necessary to control moisture by providing:

- wood components kept a minimum of 200 mm above finished ground level,
- clear granular material or a moisture impermeable material below the slab,
- damp-proofing on the foundation wall,
- free draining material or a drainage system at the exterior of the foundation wall.

Wood framing must be separated from concrete or masonry by a moisture barrier so that moisture is not drawn into the wood through capillary action. Acceptable materials include asphalt coatings, asphalt impregnated building papers and closed cell gaskets. It is also recommended that all wood framing in contact with concrete be pressure preservative treated (See Table 7.1, page 7-2).

SNOW AND ICE

Snow and ice can cause water entry in building assemblies that don't normally suffer from rain penetration. In some climates, blowing snow can enter vents and holes that are protected from rain. However, this is not usually a problem in coastal British Columbia because snow is infrequent.

A more common problem results from snow collecting on horizontal or modestly sloped surfaces, and the subsequent formation of ice that tends to block drainage paths. Snow melts in places where it receives heat from interior or exterior sources. The melt water can then run to locations where it freezes, such as at the eaves, creating a dam that restricts further drainage of melt water. The hydrostatic pressure and raised water level can lead to leakage that would not otherwise occur. Adherence to Canadian building codes and well designed flashing products will prevent this phenomena from creating a moisture problem.

VAPOUR TRANSFER FROM EXTERIOR SOURCES

There is one other mechanism of moisture transfer from outside which is worth mentioning. Vapour from a high humidity outdoor environment may be driven into the wall assembly by diffusion and air movement, where it may condense on surfaces cooled by air conditioning.

Coastal British Columbia rarely sees extended periods of hot weather, but it is possible that hot, humid conditions can be created locally at a wall. A porous cladding, such as brick or stucco, can absorb a large quantity of water in a rainstorm. The sun heating the cladding creates high vapour pressures that can drive moisture inward to cooler surfaces. This phenomenon is of particular relevance in face seal or concealed barrier assemblies. A rainscreen cavity wall provides much greater resistance to this inward vapour drive.

INTERIOR MOISTURE SOURCES

Moisture accumulation by condensation of interior humidity is generally of less concern in British Columbia's coastal climate than rain penetration, but it can add to the moisture load in building assemblies, particularly in buildings with higher than normal humidity, which is usually considered to be 40 to 60 per cent. Designers need to control this wetting mechanism.

CONDENSATION

Condensation occurs on surfaces which are colder than the dew point of the air to which they are exposed. Dew point is a measure of the absolute humidity (kgwater/kg air) of the air. Three conditions are required for condensation:

- a sufficiently cold surface,
- a source of humidity,
- a mechanism to get the humid air to the cold surface.

In a heated insulated building, condensation can occur on inside surfaces of building envelope materials or components of low thermal resistance, such as windows, or where there are strong thermal bridges. This occurs when indoor humidity migrates to cooler surfaces that are isolated from indoor heat by the insulation.

Moisture transfer through the envelope from the building interior can occur due to air movement and water vapour diffusion. In most cases, **air movement is the dominant interior moisture transfer mechanism**.

For example, consider a wall constructed of 38 x 89 mm studs with a Type II vapour barrier (whose water vapour permeance is 60 ng/Pa•s•m^2). At exterior design conditions of -15°C and 60 per cent relative humidity and interior conditions of 21°C and 58 per cent relative humidity, moisture can condense within the cavity at a rate of approximately 4 g/ m^2/day due to vapour diffusion alone. If indoor air exfiltrates through the cavity at a rate of ± 1.4 l/ m^2/s (a realistic example for older homes), the resulting rate of condensation can increase to 480 g/ m^2/day. This is more than 100 times the amount of moisture that can potentially condense due to water vapour diffusion.

The amount of water which condenses within a wall assembly due to air leakage will depend on the length of its path of travel. If air goes directly and quickly through the wall (for example, at a crack below the base plate of a wall), a relatively small amount of condensation will occur. However, if the exit path is longer, there will be more time for the air to cool and deposit condensation.

Determining potential condensation within a wall is difficult. It is governed by temperature, heat, air and vapour flow over time. Computer simulation of wall assembly performance can be used to model these processes. *EMPTIED* is one such software package. This program incorporates databases of different building materials properties. Climatic information for geographic locations across Canada is provided. The value of the program is its capacity to compare the expected relative performance of various assemblies (this information is not absolute, due to the complexity of moisture transport mechanisms). To some degree *EMPTIED* can also predict the level of airtightness which is appropriate for different assemblies.

CONDENSATION CONTROL STRATEGIES

In general, condensation can be resisted by controlling the humidity to keep the dewpoint temperature of the air below the temperature of any surface it can contact. Alternately, keep surfaces warm enough to be above the dew point of the air they contact, or isolate any cold surfaces from humid air.

Controlling Humidity

During the heating season in the British Columbia coastal climate, the indoor air contains more water than the outside air. Moisture is released into the atmosphere of a building in the following ways:

- day-to-day living activities such as breathing, cooking, bathing, washing and drying clothes,
- moisture accumulated in building materials prior to and during construction is gradually released until a point of equilibrium is reached,
- moisture accumulated in furniture and building materials during warm humid weather,
- soil moisture migrating through the basement walls or floor slab.

Many older homes have sufficient air leakage to prevent the build-up of high interior humidity levels. In newer, more airtight homes or ones in which the occupant has taken action to limit air leakage, proper ventilation is needed. Otherwise, these homes can be too humid for comfort and for building durability.

Health Canada has identified the optimum humidity range for human health as 35 to 55 per cent relative humidity unless condensation is a problem. (Elements which promote condensation at lower relative humidity levels effectively dry interior air.) Above this range, levels of bacteria, molds, mildew and mites, and susceptibility to infections and allergic reactions will be higher.

Humidity can be controlled by reducing sources or by Mechnical Ventilation. These systems, which consist of either direct exhaust fans or heat recovery ventilation, can also reduce humidity. Section 9.32 of the *British Columbia Building Code 1998* has specific requirements for installing exhaust fans in residential dwelling units to control indoor air quality and humidity levels. The mechanical ventilation system consists of one principal exhaust fan plus additional exhaust fans in every bathroom and kitchen. The principal exhaust fan is either run continuously or is connected to a time control device that will run the fan at least twice for four hours every day.

Controlling Moisture Migration Due to Air Leakage

Air leakage is a function of two factors:

- gaps in the joints, junctions and materials of an assembly through which air can flow,
- a pressure differential between the inside and the outside of a building.

Winds generally create the highest peak pressure difference across the envelope. Positive pressure occurs on the windward side of the building, forcing air in through openings. At the same time, a negative pressure on the roof and leeward side will draw air out. (Figure 3.2, page 3-7). However, wind pressure does not cause the most air leakage on an annual basis because the wind is not sustained. Continuous stack and mechanical forces usually create the most overall air movement.

Stack force is caused by the density difference between heated indoor air and unheated outdoor air. During the winter months this creates a positive pressure forcing air out of the envelope at ceiling and upper wall levels and a negative pressure drawing cooler air in through the lower portions of the building (Figure 3.5).

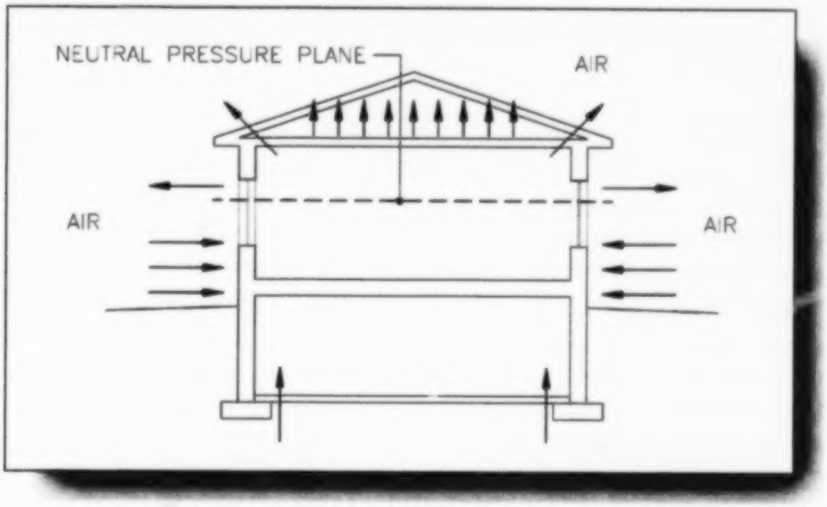


Figure 3.5: Stack effect forces

Ventilation equipment like exhaust fans and chimneys flues, help to create an interior negative pressure, drawing in outside air through openings in the building envelope (Figure 3.6). Supply fans create a positive pressure.

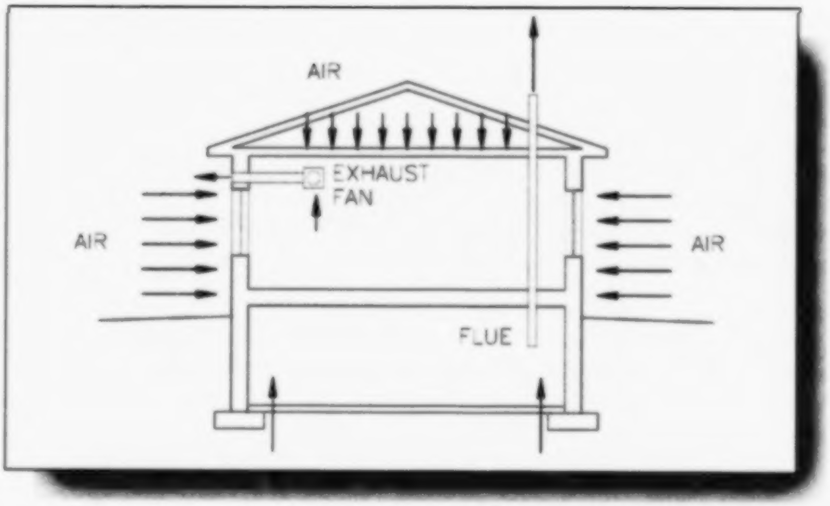


Figure 3.6: Mechanical ventilation forces

It is the outward flow of air (exfiltration) bringing indoor humidity to cold surfaces that leads to condensation. Inward flow of air (infiltration) does not normally create condensation except during the summer if the interior is air conditioned, it can create other problems such as occupant discomfort due to drafts, and can increase the likelihood of water penetration. This air flow also increases the total air change rate in the building, increasing heating and cooling loads.

An air barrier system controls air flow and is a critical component of rain penetration control. The air barrier system must comply with a number of design requirements in order to function adequately. These requirements are summarized as follows:

- All the elements of the air barrier system must be adequately air-impermeable.
- The air barrier system must be continuous throughout the building envelope. It must span across dissimilar materials and joints. It must be sealed around penetrations such as ducts and pipes.
- The air barrier system must be structurally adequate or supported to resist air pressure forces due to peak wind loads, sustained stack effect or fans.
- The air barrier system must be sufficiently rigid or supported so that displacement under pressure does not compromise its performance or that of other elements of the assembly.
- The air barrier system should have a service life as long as that of the wall and roof assembly components or alternately be easily accessible for repair or replacement.

Clause 9.25.2.2 of the *British Columbia Building Code 1998* requires an effective air barrier in all envelope assemblies. The requirements are prescriptive in nature and the British Columbia Building Code does not give quantitative criteria for acceptance. The requirements of this section include the following:

- **Where the air barrier system consists of an air impermeable, panel type material, all joints shall be sealed to prevent air leakage.**
- **Where the air barrier system consists of flexible sheet material, all joints shall be sealed or lapped and clamped between stiffer panel materials, or between closely spaced strapping.**
- **Continuity of the air barrier system shall be maintained where walls, floors and other penetrations extend through the envelope.**

The *British Columbia Building Code 1998* and Section 5.4 of the *National Building Code of Canada 1995* have further quantitative criteria for air barrier systems for buildings exceeding three storeys in building height, or 600 m^2 in building area:

- **Sheet and panel materials providing the principal resistance to air leakage shall have an air leakage characteristic of not greater than 0.02 L/s•m^2 at 75 Pa.**
- **An air barrier system shall be designed and constructed to resist 100 per cent of the wind load specified for cladding at the geographic location in which it occurs.**

For a complete description of air barrier requirements, see Section 5.4 and Appendix A-5.4 of the *National Building Code of Canada* 1995.

Air leakage performance criteria for envelope materials and components are generally specified rather than criteria for the entire building. It is difficult and costly to determine entire building air leakage rates. Also, poor performance due to excessive air leakage is usually related to specific components, materials and joints rather than the entire building.

Initial efforts to achieve a satisfactory barrier to air movement in wood-frame construction in the early 1980s focused on the use of polyethylene film. This film was structurally supported by the frame and interior sheathing, acting as a combination air/vapour barrier. This approach is still commonly and successfully employed in wood-frame buildings.

Alternate approaches to achieving control of air leakage are to seal rigid sheet materials used in construction by sealing the joints between them with gaskets or sealant. Numerous materials have a low permeability to air leakage. Table 3.1 provides some examples of material air permeability relative to the National Building Code of Canada, 1995 requirements. Not only the material, but also their joints, must be capable of staying airtight under applicable wind loads.

Unlike the vapour barrier, the air barrier may be placed on the exterior of the majority of the insulation. However, if the air barrier is located on the exterior of the wall, **it must be permeable to water vapour** or have enough insulation outside surfaces where condensation could occur to keep them above condensing temperature for most of the time. The *National Building Code of Canada 1995* identifies restrictions on the placement of air barrier materials with a water vapour permeance of less than 60 ng/Pa•s•m^2. One may also wish to avoid use of external air barriers systems made of materials with a low water vapour permeability if the framing lumber has a high moisture content, as they inhibit drying.

The discussion of air barriers in this Guide focuses on moisture management issues. However, an air barrier is also a key element for fire safety provisions, noise and ventilation control within the building.

Table 3.1: Material Air Permeability Rates

Building Materials with Tested Air Permeability Rates *below* NBC Part 5 Air Barrier Requirements	**Building Materials with Tested Air Permeability Rates *above* NBC Part 5 Air Barrier Requirements**
Polyethylene sheet	Concrete Block
Modified bituminous membranes	Particle board (15.9 mm)
Extruded polystyrene (38 mm)	Tempered hardboard (3.2 mm)
Expanded polystyrene (Type 2)	Non-perforated asphalt felt (15 lb)
Foilback urethane insulation (25.4 mm)	Perforated asphalt felt (15 lb)
Foil back gypsum board (12.7 mm)	Fibreboard (11 mm)
Plywood sheathing (8 mm)	Perforated polyethylene #1
Oriented strandboard (16 mm)	Expanded polystyrene (Type 1)
Gypsum board (12.7 mm)	Tongue-and-groove planks
Spun bonded olefin film sandwiched between two layers of fibre board	Glass-fibre insulation
Fibre board with micro-perforated polyethylene facing	Vermiculite insulation
Glass-fibre rigid insulation board with a spun bonded olefin film on one face	Cellulose insulation
Roofing felt (30 lb)	

Effective Air Barrier Systems

Three approaches to air barrier systems are discussed here and subsequently illustrated through the details in Chapter 6. These systems have been extensively tested and found to perform well under sustained wind loads and gust loads for the wood-frame buildings covered by this Guide. Some approaches may also be appropriate for larger buildings of non-combustible construction; however, the sealed polyethylene approach should not be used in these types of buildings.

Air barriers are generally located on either the interior or the exterior side of the wood-frame portion of the wall assembly. The following discussion describes several such approaches. Other systems may also perform satisfactorily and it is not intended to discourage their development.

Interior Approaches

Sealed Polyethylene Approach

The polyethylene vapour barrier is sealed at the top and bottom plates to form the wall air barrier. All joints in the polyethylene are sealed and clamped between the framing and gypsum board. The wind load is transferred to the gypsum board in the inward direction and the framing in the outward direction. The polyethylene must be supported by both the outboard insulation and the drywall on the interior. Locations where interior finishes are not normally provided, such as below the rim of bathtubs, require specific measures (installation of sheathing) to ensure support of the polyethylene.

The continuity of the air barrier at the floor header is maintained by sealing the polyethylene to the wood framing and by sealing layers of polyethylene together with sealant or gaskets, or by carrying a vapour permeable membrane to the outside of the header. Special attention has to be paid to seal penetrations of the gypsum board at electrical fixtures or other services and to carry the air barrier through the intersection of partition walls. Note that non-curing sealants are appropriate for placement between sheets of polyethylene where drying of the sealant is not possible; however, other types of sealants and gaskets are required when sealing polyethylene to wood framing or between layers of wood. See Table 7.11 (page 7-31) for guidance on sealant selection.

This interior approach can be used with most of the wall assemblies discussed in Chapter 5 and is further illustrated in the detail drawings in Chapter 6 (see Table 6.1, page 6-2).

Airtight Drywall Approach (ADA)

The interior gypsum board and framing members provide the air barrier. Continuity between different materials is created with caulking or gaskets. Special attention has to be paid to seal penetrations of the gypsum board at electrical fixtures and other services.

An advantage of this system is that the gypsum board is exposed for inspection and maintenance at all times. Nail pops, cracks and other damage must be kept repaired over the life of the building.

The paper on gypsum sheathing is very susceptible to mold growth. The lack of polyethylene in the ADA means that if moisture enters from exterior sources it has ready access to the vulnerable surface of the interior gypsum sheathing from the stud space. This can be regarded as both a positive and a negative feature, since the symptoms of a moisture problem will be seen sooner than if polyethylene was in the wall assembly; however, the potential mold and associated health hazards will have better access to the interior of the dwelling.

The airtight drywall approach can be used with most of the wall assemblies discussed in Chapter 5 and is further illustrated in detail drawings marked ADA in Chapter 6 (see Table 6.1, page 6-2).

A good source of examples of details of these interior air barrier approaches is the *Builders Manual*.

Exterior Approaches

There are several possible approaches for achieving airtightness. One approach places insulation outboard of the airtight surface. Another places the airtight surface on the exterior of the insulation. A third approach utilizes the insulation itself as the air barrier. The assemblies become more sensitive to air leakage when the air barrier is located on the exterior side of the insulation. That is, condensation is more likely to occur since cold surfaces are readily available at any discontinuities in the air barrier. The key advantage of exterior approaches is that penetrations of the interior wall finish for electrical outlets and disruptions such as stairs, plumbing fixtures and partitions, do not affect the continuity of the air barrier.

Exterior Membrane Approach

In this approach the exterior sheathing is completely covered with an adhered waterproof membrane which is vapour impermeable. Sufficient insulation is placed to the exterior side of the membrane so that condensation due to vapour diffusion is not a risk. This approach is inherent in wall assemblies such as stucco–exterior insulation rainscreen (ST-4), brick veneer–exterior insulation rainscreen (BV-2), horizontal siding–exterior insulation rainscreen (HS-3), and exterior insulation finish system–rainscreen (EIFS-1) described in Chapter 5 and is illustrated in detail drawings marked EABA in Chapter 6 (see Table 6.1, page 6-2).

Exterior Sheathing Approach

One variation of this approach known as the Exterior Airtight Sheathing Element, or EASE consists of housewrap sandwiched between two layers of fibreboard sheathing. At the ceiling level, the air barrier is created by sandwiching a polyethylene sheet between the gypsum board and fibreboard. Alternatively, the airtight drywall approach system can be used at ceiling level.

A second variation involves sealing all joints in the exterior sheathing and framing with sealant or self-adhesive membrane strips. An alternative strategy must be used over the ceiling assembly.

A third variation involves the use of housewrap that is not continuously supported in the cavity of the wall but has joints taped and is held in place by strapping at regular intervals. Again an alternative strategy must be used over the ceiling assembly.

Exterior Foam Insulation Approach

The use of sprayed in place urethane foam can be an effective means of achieving air tightness, particularly at complicated details such as at locations where floor joists penetrate the exterior wall assembly. Foam can also be used over the entire wall surface to achieve air tightness. Although some level of water tightness can be achieved with foam it is not recommended that the foam be used to perform the function of the exterior moisture barrier. A sheathing membrane or sheathing paper must be applied as the moisture barrier prior to the application of the foam.

It is worth mentioning that in face seal and concealed barrier wall assemblies the sealed surface of the cladding may in fact be the most airtight surface in the assembly, regardless of which surface was intended to be airtight. As a result, issues associated with having the air barrier on the exterior side of the insulation are relevant to these assemblies.

Regardless of which system or combination of systems is used, continuity must be maintained at joints and interruptions. Allowance must also be made to compensate for movement in framing members due to seasonal variations in moisture content or initial drying. Gasketing or sealants should be selected which will accept these movements and last the life of the assembly.

Controlling Vapour Diffusion

To avoid condensation inside an assembly, the vapour permeability of surfaces to the inside of the insulation should be lower than the vapour permeability of surfaces outside the insulation. In Canadian building practices and building codes, this is accomplished by placing a low permeability material, the vapour barrier, on the warm side of the insulation.

As a rule of thumb, the vapour barrier should have a vapour permeance three to five times less than that of the surfaces outside the insulation. Selection of an appropriate vapour barrier should be done on the basis of the permeability of other materials in the assembly. Where relatively low water vapour permeability sheathing is used, such as plywood or oriented strandboard, a Type I vapour barrier, such as polyethylene sheet or aluminum foil, may be necessary in cold climates or high humidity buildings. Where the sheathing has a high permeability to moisture, such as laminated fibreboard or spun olefin faced fibreglass board, a Type II vapour barrier or some paints are generally satisfactory.

In the British Columbia coastal climate zone, polyethylene is not required in the wall assembly to control vapour diffusion. In most commonly used wall assemblies, the quantity of moisture potentially transported through this mechanism is small and can be controlled with other vapour barriers. This is a design decision that can be made knowing the characteristics of the particular wall assembly proposed for use.

However, since polyethylene is also one of the materials commonly used to perform the function of the air barrier, its removal must be accompanied by the inclusion of an alternate air barrier strategy.

It is important to note that **the presence of polyethylene did not cause the moisture problems in the wall assemblies examined in the *Survey*, nor will its removal from wall assemblies prevent problems from occurring in the future.**

The maximum water vapour permeance of a Type I vapour barrier defined in CAN/CGSB-51.33M, *Vapour Barrier Sheet, Excluding Polyethylene, for Use in Building Construction*, is 15 ng/Pa•s•m^2. This permeance can be met by a broad range of materials including polyethylene sheet, foil, metal, and glass. A Type II vapour barrier has a maximum permeance of 60 ng/Pa•s•m^2 or less before aging.

The water vapour permeance of some materials is listed in Table 3.2. Others may be found in the *1997 ASHRAE Handbook (SI)*.

Keeping Surfaces Warm

Another way of limiting condensation is to keep surfaces above the dew point temperature of the air in contact with them. Windows are the most visible demonstration of this principle. Windows with high thermal resistance avoid condensation as well as save energy. The circulation of warm air at the surface of the window (or to another cold surface) also increases its temperature.

Condensation within walls or other building assemblies can be reduced by placing some insulation outside the building frame and sheathing. This keeps surfaces inside warmer, which will reduce or eliminate condensation.

The presence of thermal bridges such as metal window sub-sills, which pass completely from the interior to the exterior, can result in colder interior surfaces and thus can create a greater potential for condensation.

*Table 3.2: Water Vapour Permeance of Common Materials**

	Water Vapour Permeance	
Material	**Metric** ng/Pa•s•m^2	**Imperial** grain/ft.^{2}/hr. (in. Hg) = a Perm
Vapour Retarder Membranes		
0.03-mm (1-mil) aluminum foil	negligible	negligible
0.15-mm (6-mil) polyethylene	1.6-5.8	0.027-0.10
0.10-mm (4-mil) polyethylene	3.4-5.0	0.059-0.087
0.05-mm (2-mil) polyethylene	7.0-13.0	0.12-0.23
Paints		
1 coat vapour retarder paint	26	0.45
1 coat alkyd sealer plus 1 coat alkyd low lustre	28	0.48
1 coat latex sealer plus 1 coat latex paint	147-257	2.56-4.48
2 coats alkyd paint on plaster	91-172	1.58-2.99
Insulation		
25-mm (1-in.) foil-faced polyurethane	negligible	negligible
25-mm (1-in.) extruded polystyrene (Types 3 and 4)	23-92	0.40-1.60
25-mm (1-in.) extruded polystyrene (Type 2)	60-200	1.04-3.40
25-mm (1-in.) expanded polystyrene (Types 1 and 2)	115-333	2.00-5.80
100-mm (4-in.) fibreglass batts	1,666	28.97
100-mm (4-in.) rock wool	1,807	31.48
50-mm (2-in.) fibreglass batts	2,000-2,600	34.84-45.30
Framing and Sheathing		
19-mm (3/4-in.) lumber	982	17.11
6-mm (1/4-in.) exterior plywood	23-74	0.40-1.29
11-mm (7/16-in.) OSB	44-200	0.77-3.48
12.7-mm (1/2-in.) asphalt-impregnated fibreboard	2,645	46

Permeability=Permeance x thickness of materials
Perm x 57.5 = ng/Pa•s•m^2
* Vapour permeance varies from manufacturer to manufacturer.
Designers should verify the permeance of selected materials with the manufacturer.

Table 3.2: Water Vapour Permeance of Common Materials* (continued)

	Water Vapour Permeance	
Material	**Metric** ng/Pa•s•m^2	**Imperial** grain/ft.^{2}/hr. (in. Hg) = a Perm
Framing and Sheathing *(continued)*		
38-mm (1 1/2-in.) fibreglass sheathing	30-1,723	0.52-30.02
12.7-mm (1/2-in.) gypsum board sheathing	2,860	49.82
12.7-mm (1/2-in.) foil-faced gypsum board	negligible	negligible
25-mm (1/2-in.) foil-faced cellular plastic insulation	negligible	negligible
Barrier-type building paper	170-1,400	2.96-24.39
Spun-bonded polyolefin	3,646	63.51

Permeability=Permeance x thickness of materials
Perm x 57.5 = ng/Pa•s•m^2
* Vapour permeance varies from manufacturer to manufacturer.
Designers should verify the permeance of selected materials with the manufacturer.

CONSTRUCTION MOISTURE SOURCES

Although the Survey did not identify built-in construction moisture as a prevalent source of moisture leading to damage in wood frame wall assemblies, the requirement for dry lumber cannot be ignored. Closing in of wet lumber would simply create ideal conditions for decay within a wall assembly.

Several factors can create an increased potential for the presence of construction moisture and related wood decay.

RE-WETTING OF MATERIAL

Even where dry lumber is available, it can be wetted prior to and during construction. To minimize re-wetting on site, the following precautions should be taken.

- Cover lumber to protect it from standing water, rain or snow
- Store lumber flat and strapped in bundles with spacers between layers to promote ventilation
- Store lumber close to the point of use and away from moisture sources such as damp ground and new concrete.
- Install roofing, walkway and balcony membranes quickly after framing to minimize rain exposure.

WALL ASSEMBLIES AND DETAILS

Since decay is governed by moisture content, time, and temperature, the moisture tolerance of wood elements of a building assembly depends both on its tendency to absorb water and the speed at which it can dry. Impervious exterior surfaces or membranes that can reduce wetting from exterior sources may actually increase the probability of decay because they slow the drying process. An example of this phenomenon is the use of an exterior insulated rainscreen wall assembly that incorporates a self-adhesive membrane over the entire building surface. While this assembly is arguably one of the most durable and high performing wall assemblies once in service, the presence of the vapour impermeable membrane eliminates drying of the wood sheathing and framing to the exterior. Therefore if wetting does occur during construction it may be necessary to take precautions to encourage drying such as ventilating to the interior prior to the installation of any interior finishes. The lack of an interior polyethylene sheet in these assemblies will permit some drying to the interior once the drywall is installed, provided that relatively vapour permeable interior finishes are used.

Even when the use of vapour impermeable membranes is more limited, such as restricting its use to key details, it is possible to retard drying on a localized basis to the point where an elevated moisture content persists long enough to initiate decay. The use of vapour impermeable membranes at details should therefore be minimized. **In particular, applications that create a pocket restricting downward migration of moisture such as at window head locations should be avoided.**

PACE OF CONSTRUCTION

In the past, traditional frame construction adapted to, and was tolerant of, the use of green lumber, since the lumber typically had opportunity to dry significantly before being closed in. However, the rapid pace of construction that is now common requires that S-DRY lumber be specified. In addition, if site conditions lead to rewetting, the construction schedule may have to be adjusted to permit drying by natural means or to introduce forced drying. Temporary tarping and shrink-wrap enclosures can also limit wetting and allow construction to proceed on schedule.

ACCEPTABLE THRESHOLDS

The British Columbia Building Code (BCBC), 1998, article 9.3.2.5. states: "Moisture content of lumber shall be not more than 19% at the time of installation". This requirement does not specifically address wetting during construction after installation. However, the intent is that the lumber be dry and free of decay once in service.

All building assemblies generally have the ability to absorb some moisture during a wetting period and safely store it until it can dry. This is especially true for wood framed walls. The weight of wood in a one metre wide strip of plywood sheathed wall 2.54 m high is about 20 kg. It takes about 2 kg of water to raise the MC of the wood from 15% to 25% (if it is evenly distributed). Localized high moisture content can also redistribute within framed assemblies to provide acceptable moisture content.

The decision regarding acceptable initial moisture content, the rate at which drying and redistribution will occur once the lumber is closed in requires considerable judgment. It is also an area that would benefit from further research. At the present time it is therefore advisable to be conservative in the assessment of acceptable moisture content for specific site situations.

It is also possible to monitor the moisture content of lumber that has been enclosed to verify that it is drying and the rate at which it is drying. In some circumstances this approach may be used to determine an acceptable time frame for closing in wall assemblies, or alternately to verify acceptability of assemblies or details that have already been closed in. Use of tools to measure moisture content of wood products requires some knowledge of variables and factors affecting the measurements; further information is available from CMHC under title "Guidelines for On-site Measurement of Moisture in Wood Building Materials".

DEFLECTION, DRAINAGE AND DRYING

As emphasized earlier in this chapter, moisture control requires a balance between wetting and drying mechanisms. To avoid major problems, designers must not only eliminate sources, they must address removal mechanisms. For example, using a sealing type coating may reduce moisture movement into and out of the cladding by 90 per cent. However, if water entry through the cladding is only 50 per cent of the total entry from all sources, and drying through the cladding is the main source of moisture removal, the moisture balance has been tipped in favor of moisture accumulation. Many problems with stucco and exterior insulation finish systems in British Columbia can be attributed to the fact that these types of walls have a limited ability to drain and dry once water gets behind the cladding, whether that water entered through the cladding or elsewhere.

Deflection, while not a drying mechanism, is the first priority in assuring moisture removal. If most of the water is diverted before it has a chance to impact on and enter the wall assembly, then drainage and drying requirements are significantly reduced.

Water can be removed by drainage, or wicking (capillary action) through porous materials. Vapour moves by diffusion and evaporation toward a dryer atmosphere.

Provision for the drainage of large quantities of water is important in wet climates. This is a major advantage of drained cavity or rainscreen wall assemblies. Sloping roofs, decks, balconies and walkways are fundamental for effective drainage of horizontal features. If the drainage passages are too narrow, drainage is impeded, a particular concern with scuppers. Capillary action, or surface tension, also impedes water movement through small orifices. An air space to the outside of the drained surface is generally required for good drainage.

Draining water must be intercepted at appropriate locations and directed to the outside by properly detailed flashing. Flashing should be sloped to the outside. When the flashing is interrupted, it should have end dams to stop water running off the ends. **Poor flashing detailing is a major cause of moisture problems in buildings.** The publication, *Best Practice Guide: Flashings* provides detailed discussions on flashing design.

The drying ability of the insulated assembly depends on the capacity of the sheathing and cladding systems to allow water vapour to migrate through them. Studies have been conducted to determine the drying rates of walls with various commonly available sheathing materials. Their ranking is as follows:

- Fastest: Fibreglass sheathing board and wood fibre board
- Relatively Fast: Plywood and OSB (wood-based products)
- Less Fast: Extruded polystyrene

- Least Fast: Laminated polyisocyanurate

Of these materials, the glass fibre and wood products have the ability to wick water away. They have a good capacity for drying. The successful use of foam insulation boards depends on their ability to maintain a warmer temperature in the stud cavity. High permeability to water vapour diffusion is desirable in exterior sheathing materials.

Where dry lumber is accidentally wetted, it is desirable to use exterior sheathings which permit fast drying. Foamed plastic insulation, particularly those faced with foil, are less suitable because they significantly restrict drying to the exterior.

The driving forces for drying include internal heat sources, solar heating (which can drive moisture in under some circumstances), and air movement. The drying process is enhanced in many wall assemblies by creating a ventilation space or cavity between the cladding and the sheathing. For example, when masonry veneer is used, a cavity is provided behind the brick. When other siding systems are used, they can incorporate strapping to create a cavity. How much venting is needed to enhance drying is the subject of considerable ongoing research.

KEY POINTS

- Deflection is the primary moisture control mechnism since it eliminates the potential for water to impact on or enter an envelope assembly. Drainage is the next most important mechanism. If water enters the assembly, it must be redirected out of the assembly. Any moisture that doesn't drain quickly must be able to dry. Since the drying moisture removal mechanism is slower than deflection and drainage, it is a second line of defense and should not be relied upon to the same extent. Surfaces upon which moisture rests must be durable enough to accommodate the moisture until it drains or dries.
- Three conditions are required to move water through a material:
  - a source of water at the surface
  - openings through which it can pass
  - a force to move the water through the openings.

The elimination of any one of these three conditions will prevent water entry.

- Assemblies using a face seal strategy have proven to be less reliable because installing and maintaining perfect and durable seals at all joints and intersections between assemblies is very difficult.
- Failed joints and penetrations are the primary entry path for exterior water into wall assemblies.
- Air movement is the dominant interior moisture transfer mechanism.
- The introduction of a cavity to the assembly does not eliminate the need to address exposure by deflection or the need to limit major water entry paths.
- An effective air barrier is the most critical aspect of managing air pressure differentials and, consequently, rainscreen performance. Some compartmentalization of the cavity, particularly at corners, is necessary.
- Isolating facades by sealing the corners of cavities dramatically reduces driving pressures across the rainscreen, reducing the potential for and magnitude of water entry.

- **Corner seals in cavities must be strong. They should be designed to withstand twice the structural wind load.**
- **The presence of polyethylene did not cause the moisture problems in the wall assemblies examined in the *Survey*, nor will its removal from wall assemblies prevent problems from occurring in the future.**
- **The use of a less sensitive wall assembly does not eliminate the need for good details and construction practice.**

CHAPTER 4

HEAT FLOW

The largest component of total energy consumption for Canadian buildings is heating (fall, winter and spring). For most British Columbia coastal zone residential buildings, this heating requirement is between 30 and 60 per cent of the total energy consumption.

Retaining heat is a primary function of the building envelope. A basic principle of physics is that heat flows from an area of higher temperature to one of lower temperature. While the flow cannot be prevented, it can be controlled to decrease the total energy consumption of the building.

Heat flow is also a major factor in the flow of moisture through building envelope assemblies. It can be a driving force for both wetting and drying mechanisms.

MECHANISMS OF HEAT FLOW

There are four principal mechanisms of heat transfer through the building envelope:

- **Conduction:** Heat is conducted at the molecular level through the envelope materials. The rate of heat flow depends on the materials present. Every material has a different capacity to resist conductive heat flow which is expressed as an RSI (metric) value or R (imperial) value.
- **Convection:** Heat transfer increases where convection currents are present in the assembly. Convection loops effectively bypass the thermal resistance of the insulation and may transfer significantly more heat than is transferred by conduction. Convection currents can be resisted by installing the insulation to completely fill the cavity so that it is in intimate contact with the air barrier.
- **Air Leakage:** The leakage of heated interior air through the assembly results in a direct loss of heat to the exterior. An effective air barrier system will substantially reduce this mechanism of heat loss.
- **Radiation:** Radiant heat transfer differs from conduction and convection in that it does not depend on an intermediate material as a carrier of energy. It requires a medium (such as glass or air) which is transparent to the electromagnetic spectrum of the radiated energy. This heat flow mechanism is not generally significant to moisture management or the behaviour of the opaque portion of wall and roof assemblies described in this Guide. However, night sky radiation may result in some short-term collection of moisture on the underside of roof sheathing.

The primary means of controlling heat flow from wood-frame buildings has been to place insulation from stud cavities and attics. More recently, rigid and semi-rigid board insulation has been placed on the exterior of the stud wall assembly.

The selection of insulation for wall cavities is based on a variety of factors including cost, availability, and acoustic and thermal performance. Fibreglass is the most commonly used material.

Sprayed cellulose insulation contains water which will raise the moisture content of the framing. Therefore, the wall cavity should be allowed to dry before the installation of the interior vapour barrier and a vapour permeable wall sheathing should be used. The potential for fungal growth due to the water is normally offset by the presence of fungicide in the spray application. This must be verified with the manufacturer.

Sprayed urethane insulation is relatively vapour impermeable and will not permit drying of the encased framing lumber. Care should be taken to avoid conditions where the wood is fully encased when using this material.

The thermal resistance of materials commonly used in wood-frame construction can be found in Table 7.2, page 7-4.

THERMAL BRIDGING EFFECTS AND CONTROL

Wood has a lower thermal resistance than the insulation materials used between the framing members. More heat flow will occur through a stud, wall plate or joist than at other locations in the framed wall or roof assembly. This increase in thermal conductivity is referred to as thermal bridging.

Condensation due to thermal bridging at studs is usually not a significant issue in wood-frame construction. It is occasionally found in wood-frame buildings, showing up as discolouration or mildew on walls, typically in the corners of rooms. Condensation on interior wall surfaces, due to thermal bridging in wood framing, will generally only occur in the presence of some of the following factors:

- high interior humidity,
- poor circulation of interior air (pockets of low convection, such as corners of rooms and at ceilings),
- the presence of large masses of framing material in the wall, such as multiple studs and plates at corners, and the absence of insulated sheathing,
- poorly installed cavity insulation.

Thermal performance of the wall assembly is reduced as a result of thermal bridging. About 15 per cent of the wall area is occupied by framing material, depending on stud spacing and layout.

With the drive to build more energy-efficient housing, higher insulation levels are being used than were used in buildings 20 years ago. The most common and cost effective way of accomplishing this in walls has been to increase the stud depth from 89 mm to 140 mm and to add more insulation to the stud space. Other techniques include application of insulating sheathing to one face of the studs, or the addition of insulation to the outside of the exterior sheathing. Insulating sheathings have the added benefit of decreasing thermal bridging effects and of reducing the potential for condensation within the wall assembly.

THERMAL PERFORMANCE STRATEGIES AND REQUIREMENTS

Canada's new *Model National Energy Code of Canada for Houses 1997* establishes energy performance requirements for buildings based on cost benefit analysis. It considers the following criteria on a region-by-region basis:

- climate,
- fuel types,
- fuel costs,
- construction costs.

The thermal performance levels in this new code refer to the entire assembly, not the value of the insulation found in the cavities. Thermal bridging is accounted for in meeting the requirements whereas it has generally not been considered by other codes when prescribing insulation levels. A summary of the suggested requirements for British Columbia's coastal zone is provided in Table 4.1.

Table 4.1: Minimum Effective RSI Values for British Columbia's Coastal Zone

	Minimum Effective Thermal Resistance RSI (R)	
	Principal Heating Source	
	Natural Gas	Electricity, Oil, Propane or Air to Air Heat Pump
Roofs		
Type I: attic type, pitch chord truss	5.40 (R30)	7.00 (R40)
Type II: all others (for example, sawn lumber joist, parallel-chord truss and wood I joist)	4.30 (R24)	4.30 (R24)
Above-Grade Walls	2.00 (R11)	3.10 (R18)
Below-Grade Walls	1.70 (R10) @ 600 mm below grade	2.10 (R12) @ 600 mm below grade
(adapted from *Model National Energy Code of Canada for Houses 1997* for Region A, British Columbia)		

Section 9.25.2 of the *British Columbia Building Code 1998* and the 1999 version of the *Vancouver Building By-Law* generally provide prescriptive insulation requirements based on the insulating value of the primary insulating material only, rather than the entire wall assembly. Both permit the use of simulation programs to arrive at alternate insulation levels based on overall performance criteria. Their prescriptive requirements are summarized in Table 4.2.

Table 4.2: British Columbia Building Code and Vancouver [illegible] Nominal Insulation Values

	Insulating Value of Primary Insulating Material RSI (R)	
	Principal Heating Source	
	Natural Gas	Electricity, Oil, Propane or Air to Air Heat Pump
B.C. Building Code		
Roofs		
Type I: attic type, pitch chord truss	7.0 (R40)	7.0 (R40)
Type II: all others (for example, sawn lumber joist, parallel-chord truss and wood I joist)	4.9 (R28)	4.9 (R28)
Above-Grade Walls	2.45 (R14)	3.5 (R20)
Below-Grade Walls	2.1 (R12)	2.1 (R12)
Vancouver Building By-Law–Part 9		
Roofs	4.2 (R24)	7.0 (R40)
Walls	2.45 (R14)	3.5 (R20)
Vancouver Building By-Law–Part 3		
Roofs	3.5 (R20)	3.5 (R20)
Walls	2.1 (R12)	2.1 (R12)

KEY POINTS

- Heat flow is also a major factor in the flow of moisture through building envelope assemblies. It can be a driving force for both wetting and drying mechanisms.
- Condensation due to thermal bridging at studs is usually not a significant issue in wood-frame construction.

SYSTEM REQUIREMENTS

GENERAL

A summary of building envelope functions is presented below, based on *Requirements for Exterior Walls, Canadian Building Digest No. 48*:

- Control heat flow
- Control air flow
- Control water vapour flow
- Control rain penetration
- Control light, solar and other radiation
- Control noise
- Control fire and smoke
- Provide security
- Transfer structural loads
- Be durable
- Be economical
- Be aesthetically pleasing and marketable
- Provide privacy and views
- Be constructable
- Interact with mechanical system
- Be maintainable

All of these functions need to be considered in the complete design of the building envelope, but the design for moisture management purposes should not be sacrificed to meet some other objective. The designer must accommodate all of the purposes of the building envelope and develop a building envelope which meets all objectives and performance criteria.

Chapters 5, 6 and 7 provide guidance on the selection and design of appropriate assemblies, details, components and materials in order to manage moisture sources which affect the building envelope. Chapter 5 considers moisture management in the context of overall wall, window, roof and deck, and balcony and walkway assemblies. Chapter 6 considers moisture management at details, either where assemblies intersect or where various penetrations of the assemblies occur. Chapter 7 provides guidance for the selection of components and materials in relation to moisture management performance.

The intent of this chapter is to assist in the selection of appropriate assemblies exposed to exterior moisture sources. Its focus is on the moisture management problems identified in the *Survey*. This focus on exterior sources is not intended to minimize the need to design and manage all sources of moisture. The generic assemblies presented are those likely to be considered in wood-frame residential construction. Each assembly is described by its cladding type and the basic strategy for controlling external moisture sources (face seal, concealed barrier, and rainscreen). This approach has been previously used by the British Columbia Housing and Management Commission in *HOMES BC 1997, Non-Profit Development Guidelines*.

No differentiation is made between rainscreen and pressure equalized rainscreen assemblies, since the differences in these assemblies are primarily associated with details designed to limit the air pressure differential across the cladding. Compartmentalization, other than at corners, provides only minimal incremental improvements in performance for the types of buildings and assemblies for which this Guide is intended. In very high exposure areas where better pressure equalization characteristics are warranted, the designer must provide the special requirements and details for construction that are needed.

The assemblies are presented in data sheet format, including a description of the assembly and a discussion of the moisture control strategies used. In addition, each data sheet describes the limitations of the assembly. These limitations may reflect suitability for certain exterior exposure conditions, interior conditions or limitations in our current knowledge regarding the long-term performance of these assemblies. Also included is an overview of the long-term performance expectations of the assembly, based on available documentation. Finally, there is a discussion of the relative sensitivity of the assembly to moisture, detailing and construction quality control.

Examples of detailing for several of the wall assemblies and three different airtightness strategies are presented in Chapter 6.

The assemblies shown include many which are commonly used. Several less common assemblies are also presented. These assemblies are almost all rainscreen assemblies which incorporate the better moisture control strategies discussed in Chapter 3. While not common in the British Columbia coastal climate zone at present, many of the assemblies are in common usage in other parts of North America and in Europe. Rainscreen assemblies generally have a much lower risk of moisture-related problems, but they also have a higher initial construction cost. The higher initial costs are generally balanced by lower maintenance and renewal costs.

It may be possible to use variations of the assemblies shown, as well as other assemblies not presented in this Guide. In this case, ensure that appropriate consideration is given to each of the variables affecting their performance. Performance testing of new or alternate assemblies is required to determine their performance characteristics.

MOISTURE BARRIER

The moisture barrier is the surface farthest from the exterior which can accommodate moisture without incurring damage to the assembly. It is not always easy to establish this surface since some surfaces can accommodate small amounts of moisture for a limited time without damage, while larger quantities of water or longer exposure to moisture will lead to premature deterioration or migration of moisture further into the assembly. The assemblies shown use the strategies discussed in Chapter 3 for control of exterior moisture. The particular strategy used is discussed on each data sheet.

To assist in evaluating the potential performance of assemblies, and in particular those not specifically discussed in this chapter, Table 5.1 should be considered. Note that the table is only applicable to wall and window assemblies, as most horizontal envelope assemblies (roofs, decks, balconies and walkways) used in low-rise wood-frame construction will use a face seal strategy (water shedding or waterproof membrane).

Table 5.1 compares general performance expectations for four exterior moisture control strategies in four exposure categories: high, medium, low

Table 5.1: Performance Expectations for Exterior Wall and [illegible]

Exposure Level	Face Seal	Concealed Barrier	Rainscreen	Pressure Equalized Rainscreen
High	Poor	Poor	Fair	Good
Medium	Poor	Poor	Good	Good
Low	Fair	Good	Good	Good
None	Good	Good	Good	Good

and none. While these ranges are somewhat arbitrary and require an assessment by the designer, they are summarized as follows:

• High	Wall is regularly wet under normal service conditions and is subject to significant exposure to wind
• Medium	Wall is often wet under normal service conditions
• Low	Wall is rarely wet under normal service conditions
• None	Wall is never wet under normal service conditions

An example of a wall in exposure category None would be a recessed ground floor level wall effectively protected from wetting by large overhangs.

The three categories of expected performance are also somewhat arbitrary in their definition:

- Good – Wall assembly is likely to meet its expected performance criteria. There is low risk of failure during the intended service life, provided an appropriate maintenance program is adhered to.
- Fair – Wall assembly may meet its expected performance criteria although the performance will be very dependent on quality of details, maintenance activity, and local exposure conditions. There is a significant risk of failure within the expected service life of the assembly.
- Poor – Wall assembly is not likely to meet its expected performance criteria. There is an unacceptable risk of failure occurring during the intended service life of the assembly.

Exposure

Design and environmental factors will determine exposure level. Design factors range from building orientation to building features which deflect water. Environmental factors include the duration and intensity of rainfall, and wind velocity and the orientation during these rain events. Together these factors will determine how often, and for how long, the building walls will be wet. The process of evaluating exposure can be simplified by considering only the three most influential factors: climate, overhang and terrain.

Although the British Columbia coastal climate zone contains various micro-climate zones where rainfall intensity and wind directions vary, it is reasonable to establish the entire coastal climate zone as a severe wetting environment for the determination of building exposure categories. Therefore the discussion which follows does not consider climate to be a variable.

An overhang is usually created by the roof but may also be created by other features of the building such as awnings or floor assemblies which are extended. An overhang ratio can be defined as:

$$\text{Overhang Ratio} = \frac{\text{Overhang Width}}{\text{Wall Height}}$$

Where:

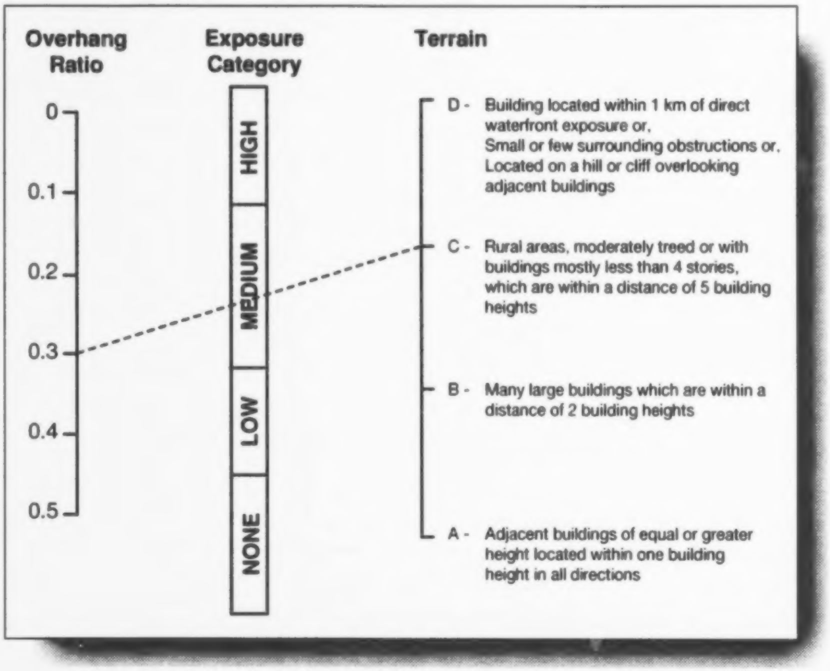
Wall Height is the height above the lowest affected wood element (and would therefore not include concrete foundation wall height).

Overhang Width is the horizontal distance between the outer surface of the cladding and the outer surface of the overhang.

Terrain has a large influence on how much wind-driven rain will impact on the walls of a building. For the purposes of this Guide, four categories have been defined. They are described in Figure 5.1.

The nomograph in Figure 5.1 can be used to determine a general exposure category for different combinations of overhang ratios and terrain. The scale A to D in Figure 5.1 represents most-sheltered locations–A to least-sheltered locations–D. Climate is assumed to be the coastal climate zone for all combinations of overhang and terrain. A straight line drawn between a calculated overhang ratio and an appropriate terrain description will pass through the exposure category bar to obtain an exposure rating. The dotted line on the nomograph below represents a situation where overhang ratio = 0.3, Terrain class is C, and the resulting exposure category is medium.

The width of the exposure bar is intended to indicate the variability in this simplified approach. The designer should also review the site location, localized climate factors, and building features in detail before completing



D - Building located within 1 km of direct waterfront exposure or, Small or few surrounding obstructions or, Located on a hill or cliff overlooking adjacent buildings

C - Rural areas, moderately treed or with buildings mostly less than 4 stories, which are within a distance of 5 building heights

B - Many large buildings which are within a distance of 2 building heights

A - Adjacent buildings of equal or greater height located within one building height in all directions

Figure 5.1: Exposure category nomograph

the assessment of exposure category. The assemblies in the next section have been assigned recommended maximum exposure ratings.

It is recommended that the selection of the wall assemblies be based on the highest exposure category for any location on a building. It is possible to design large wall areas for different exposure conditions on the same building; however, there is increased detailing complexity when combining more than one strategy. For example, the transition between a face seal and a rainscreen assembly can be difficult.

AIR BARRIER

Usually, the selection of the assembly can be considered somewhat independently of the air barrier system to be employed because the air barrier system can use any of the strategies discussed in Chapter 3. Different materials within the assembly can be employed. Regardless of the air barrier system selected, the focus needs to be on continuity at details. Air barrier continuity at details is presented in Chapter 6.

VAPOUR BARRIER

Most of the assemblies shown use polyethylene located to the exterior side of the interior gypsum board as the vapour barrier. There are assemblies where some insulation is located on the exterior side of the exterior sheathing. In these assemblies, the vapour barrier is the adhered waterproof sheathing membrane which is placed against the sheathing. Polyethylene sheet should not be used in these assemblies.

DRYING

The preceding three sections (Moisture Barrier, Air Barrier and Vapour Barrier) discuss critical barriers that control the migration of moisture into the assembly. Chapter 3 also presents four general strategies for managing moisture: Deflection, Drainage, Drying and Durability. While the basic principles regarding these critical barriers and moisture management strategies may be readily understood there is a need for further research to quantify the impact of variables on the application of each strategy. The drying mechanism is perhaps the area where the least data is currently available. A recent study (Envelope Drying Rates Experiment) focuses on drying in an attempt to better define the key parameters impacting the ability of a wall assembly to dry.

The testing confirmed that walls can dry to the exterior but that there is substantial variation in the drying rates. It was found that a 19mm cavity behind the cladding provided significantly better performance than either 10mm cavity or 0mm cavity widths. Venting at both the top and bottom of the walls provided only marginal improvement over venting at the bottom of the cavity only.

It should be noted that the testing was limited in scope and can not be extrapolated to represent wetting and drying of actual wall assemblies. For example, the test program did not attempt to include the effects of air leakage on drying, nor did it model water ingress and the continuous nature of some moisture sources. Further testing is planned that will explore the impact of other parameters on drying rates.

The results of this study suggest that while drying can not be relied upon as the key moisture management strategy for a wall assembly, walls can be designed and constructed to incorporate features that facilitate drying, such as the use of 19mm cavities behind the cladding. The consideration of these variables in addition to basic water vapour permeance characteristics of materials can result in walls that are less sensitive to the presence of minor amounts of moisture.

INSULATION

The majority of the assemblies shown use fibreglass batt insulation solely within the stud cavity. Some assemblies also show semi-rigid fibreglass on the outside of the exterior sheathing. For each assembly, a table lists the effective RSI and R values for the layers in the assembly, both for 38 x 89 mm studs and 38 x 140 mm studs in walls (both at 400 mm spacing), and for 38 x 235 mm roof joists. Note that the effective RSI value of the batt insulation is de-rated slightly to reflect the thermal bridging of the stud or joist. (See assemblies beginning on page 5-8).

Table 5.2: Effective Insulation Values

Fibreglass batt insulation rating	Effective value in stud wall
RSI 1.76 (R10)	RSI 1.7 (R9.5)
RSI 2.1 (R12)	RSI 2.0 (R11.25)
RSI 2.46 (R14)	RSI 2.3 (R13.0)
Building Code requirements are based on the nominal insulation value, not the effective RSI.	

DURABILITY

The bottom of each data sheet discusses particular durability issues for the assembly. The actual life expectancy is very dependent on a variety of in-service factors such as exposure, climate, and maintenance. The discussion therefore focuses on appropriate selection of materials, components and assemblies during the initial design and construction, so that the design service life and functions of the assembly may be realized.

The discussion also deals with the relative durability requirements of particular components in the assembly. For example, the expected durability of components hidden behind the cladding should have a life expectancy that is equal to, or exceeds, that of the cladding itself. Otherwise, the repair or replacement of these components will necessitate the removal or destruction of a component which still has some service life remaining.

Durability also influences maintenance and renewal plans. Issues relevant to maintenance and renewal are discussed. An appropriate plan should be prepared by the design team. Maintenance and renewal planning is discussed further in Chapter 9.

ASSEMBLIES EXTERNAL TO MAIN ENVIRONMENTAL SEPARATOR

External elements are often not environmental separators, such as divider walls between balconies, or external columns. They do not separate indoor and outdoor environments and therefore are not subjected to some of the major driving forces for both wetting and drying. They are usually uninsulated assemblies, although sometimes they are acoustically insulated. In most cases these elements still need to manage external moisture sources in the same way that other building envelope assemblies do. These elements are usually completely enclosed and usually can only dry to the exterior if wetted. While none of these assemblies are presented in this chapter, they should be designed, detailed and constructed to meet the same performance criteria as an insulated wall assembly for given exposure conditions. In addition, they should be vented to the exterior. Pressure-treated wood should be used as discussed in Chapters 2 and 7. Venting details are provided in Chapter 6.

CRAWL SPACES

Two strategies exist for managing moisture in crawl spaces. They can be considered as being entirely outside the structure, with all the special considerations attendant to that situation in the coastal climate. Alternately, they can be considered part of the indoor environment and constructed with the same attention to detail for moisture control as upper storeys. Except in the Far North when building over permafrost, the majority of crawl space installations in Canada and British Columbia should be treated as indoor space.

Within crawl spaces, as in full basements, ensuring proper drainage, preventing wood from coming in contact with moisture sources, installing effective ground cover and ensuring proper air exchange in the space are needed to ensure that conditions for maintaining a durable structure are present. Shallow crawl spaces are more difficult to inspect and maintain. In these circumstances, it may be more appropriate to install a ground floor slab with no space under it.

STRUCTURAL ISSUES

The sizes of studs and joists, as well as the thicknesses of sheathing products, are arbitrary and are shown only as examples, such as for the calculation of thermal insulation values. All structural requirements associated with these assemblies must be determined on an individual building basis. In addition to the wood framing and sheathing which forms the primary structure, fasteners for the attachment of the cladding to the primary structure, or design of the strapping and its attachment to the structure also need to be determined.

The determination of fastener requirements for a particular project must consider cladding weight, imposed lateral loads (wind and earthquake), strapping size and spacing, sheathing type and thickness in addition to the wide variety of fastener options that exist. For example, the use of strapped cavity stucco wall assembly introduces some additional considerations in accommodating and transferring not only vertical but lateral loads:

- **Cladding Attachment to Strapping**–The cladding must be attached so that it carries the loads and does not disengage when it is loaded. For stucco cladding this may dictate the use of 50mm stainless steel staples at 150mm o/c with the strapping at 400mm spacing.
- **Strapping Attachment to Framing**–The strapping must be attached to the sheathing and stud framing so that it effectively transfers vertical and lateral loads. For heavier claddings such as stucco and 19mm thick strapping this may dictate the use of 64mm nails at 300mm o/c on stud lines with the strapping located at 400mm spacing.

In some cases it may be appropriate to combine the reinforcing lath and strapping attachment systems. This could be accomplished by nominally fastening the strapping before placing the reinforcing lath, and then attaching the lath with longer fasteners through to the studs.

WALL ASSEMBLIES

Ten different wall assemblies are presented in this section.

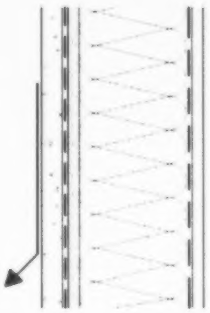
Table 5.3 summarizes the assemblies recommended for differing exposure levels. Refer to the individual assembly sheets for a more detailed explanation of the performance expectations in varying exposure levels.

The arrow on each sketch indicates the moisture barrier surface for each assembly. This helps in differentiating between otherwise similar assemblies such as stucco–face seal (ST-1) and stucco–concealed barrier (ST-2).

Table 5.3: Recommended Wall Assemblies for Exposure Categories

WALL ASSEMBLIES	EXPOSURE LEVEL			
	None	Low	Medium	High
ST-1: Stucco–Face Seal	✓			
ST-2: Stucco–Concealed Barrier	✓	✓		
ST-3: Stucco–Rainscreen	✓	✓	✓	
ST-4: Stucco–Exterior Insulation Rainscreen	✓	✓	✓	✓
BV-1: Brick Veneer–Rainscreen	✓	✓	✓	
BV-2: Brick Veneer–Exterior Insulation Rainscreen	✓	✓	✓	✓
HS-1: Horizontal Siding–Concealed Barrier	✓	✓		
HS-2: Horizontal Siding–Rainscreen	✓	✓	✓	
HS-3: Horizontal Siding–Exterior Insulation Rainscreen	✓	✓	✓	✓
EIFS-1: Exterior Insulation Finish System–Rainscreen	✓	✓	✓	

ST-1: Stucco–Face Seal Wall Assembly

		Effective RSI (R) 38 X 89	Effective RSI (R) 38 X 140
	AIR FILM	0.03 (0.17)	0.03 (0.17)
	22 mm STUCCO (MOISTURE BARRIER)	0.14 (0.80)	0.14 (0.80)
	SHEATHING PAPER	0	0
	12 mm WOOD SHEATHING	0.11 (0.60)	0.11 (0.60)
	INSULATION IN STUD SPACE	1.98 (11.25)	3.26 (18.50)
	6 mil POLYETHYLENE	0	0
	12 mm INTERIOR GYPSUM BOARD	0.08 (0.45)	0.08 (0.45)
	AIR FILM	0.12 (0.68)	0.12 (0.68)
	TOTAL	**2.46 (13.95)**	**3.73 (21.20)**

MOISTURE BARRIER (identified with an arrow on the sketch)
This assembly anticipates the control of all the exterior moisture at the exterior cladding. Any moisture that penetrates past the face seal cannot be readily accommodated by the wall assembly.

AIR BARRIER
All three air barrier strategies can be used for this wall assembly. The nature of this cladding material makes it inherently airtight and may in fact make the stucco the most airtight element in the assembly regardless of the intended airtightness strategy.

VAPOUR BARRIER
Polyethylene acts as the vapour barrier for interior moisture sources. However, it limits the amount of drying to the interior which can occur. This wall assembly is sensitive to moisture ingress from any source. The use of heavy sheathing papers and some coatings on the stucco may restrict vapour diffusion to the exterior, further contributing to the sensitive nature of the assembly.

LIMITATIONS ON USE
Good performance can be expected only under conditions where the assembly is not wetted from the exterior.

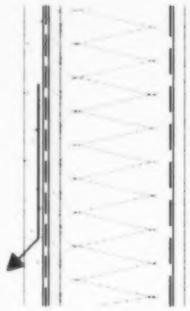
DOCUMENTED LIMITATIONS
These assemblies have a recent history of very poor performance in medium and high exposure conditions. This poor performance has been well documented.

DURABILITY
The assembly is very sensitive to the continuity of the face seal. The interfaces and finishes need to be maintained and the amount of water impacting on the assembly should be minimized. These are both significant factors in the overall performance and durability of the assembly.

Recoating the stucco surface decreases its drying capability to the exterior and should be undertaken with caution.

Stucco assemblies are sensitive to frame shrinkage. Failure to provide appropriate control joints can result in stresses and possibly cracking in the stucco.

ST-2: Stucco–Concealed Barrier Wall Assembly

		Effective RSI (R) 38 X 89	Effective RSI (R) 38 X 140
	AIR FILM	0.03 (0.17)	0.03 (0.17)
	22 mm STUCCO	0.14 (0.80)	0.14 (0.80)
	SHEATHING PAPER (MOISTURE BARRIER)	0	0
	12 mm WOOD SHEATHING	0.11 (0.60)	0.11 (0.60)
	INSULATION IN STUD SPACE	1.98 (11.25)	3.26 (18.50)
	6 mil POLYETHYLENE	0	0
	12 mm INTERIOR GYPSUM BOARD	0.08 (0.45)	0.08 (0.45)
	AIR FILM	0.12 (0.68)	0.12 (0.68)
	TOTAL	**2.46 (13.95)**	**3.73 (21.20)**

MOISTURE BARRIER (identified with an arrow on the sketch)

This assembly anticipates the control of the majority of the exterior moisture at the exterior cladding while recognizing that a minor amount of incidental moisture will likely migrate beyond the exterior cladding. This moisture is allowed to drain through a series of small interconnected cavities formed between the stucco and building paper. The assembly incorporates flashing to direct this incidental moisture out of the assembly at the base of the wall.

AIR BARRIER

All three air barrier strategies can be used for this wall assembly. The nature of this cladding material makes it inherently airtight and may in fact make the stucco the most airtight element in the assembly regardless of the intended airtightness strategy.

VAPOUR BARRIER

Polyethylene acts as the vapour barrier for interior moisture sources. However, it limits the amount of drying which can occur to the interior. This wall assembly is sensitive to moisture ingress from any source. The use of heavy sheathing papers and some coatings on the stucco may restrict vapour diffusion to the exterior, further contributing to the sensitive nature of the assembly.

LIMITATIONS ON USE

The secondary drainage cavities are very dependent on the actual construction materials used. The cavity can only be created with types of stucco reinforcement and sheathing papers which encourage the formation of a dimpled appearance to the back surface of the stucco. With the small cavity, capillarity (surface tension) will restrict the amount of drainage which can occur. Good performance can be expected only under conditions where the assembly is rarely wetted from the exterior (low exposure).

DOCUMENTED LIMITATIONS

These assemblies have a recent history of poor performance in medium and high exposure conditions. This performance has been well documented.

DURABILITY

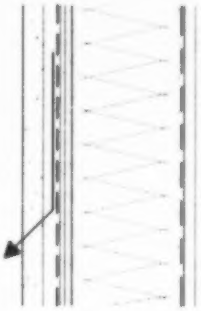
The assembly is sensitive to moisture which reaches the exterior sheathing and framing. Therefore, detailing of the interfaces and minimizing the amount of water impacting on the assembly are both significant factors in achieving overall performance and durability.

Since it is anticipated that some water will penetrate past the cladding, the fasteners used to secure the lath, the sheathing paper and the flashing must have a service life that is at least as long as that of the stucco.

Recoating the stucco surface decreases its drying capability to the exterior and should be undertaken with caution.

Stucco assemblies are sensitive to frame shrinkage. Failure to provide appropriate control joints can result in stresses and possibly cracking in the stucco.

ST-3: Stucco–Rainscreen Wall Assembly

		Effective RSI (R) 38 X 89	Effective RSI (R) 38 X 140
	AIR FILM	0.03 (0.17)	0.03 (0.17)
	22 mm STUCCO	0.14 (0.80)	0.14 (0.80)
	19 mm CAVITY, P.T. WOOD STRAPPING	0.16 (0.90)	0.16 (0.90)
	SHEATHING PAPER (MOISTURE BARRIER)	0	0
	12 mm WOOD SHEATHING	0.11 (0.60)	0.11 (0.60)
	INSULATION IN STUD SPACE	1.98 (11.25)	3.26 (18.50)
	6 mil POLYETHYLENE	0	0
	12 mm INTERIOR GYPSUM BOARD	0.08 (0.45)	0.08 (0.45)
	AIR FILM	0.12 (0.68)	0.12 (0.68)
	TOTAL	**2.61 (14.85)**	**3.89 (22.10)**

MOISTURE BARRIER (identified with an arrow on the sketch)

This assembly anticipates control of the majority of exterior moisture at the exterior cladding while recognizing that some incidental moisture will likely migrate beyond the exterior cladding. This moisture is allowed to drain down the cavity formed behind the exterior cladding, and out of the assembly at cross-cavity flashing locations. Further drying of the cavity is facilitated by evaporation through air exchange in the cavity as well as limited moisture diffusion through the stucco.

AIR BARRIER

All three air barrier strategies can be used for this wall assembly. The use of a rainscreen stucco assembly means that wall assembly components and materials other than the stucco itself must be relied upon to achieve acceptable airtightness performance.

VAPOUR BARRIER

Polyethylene acts as the vapour barrier for interior moisture sources. It limits the amount of drying which can occur to the interior, however due to the presence of the cavity there is drying potential to the exterior. The use of heavy sheathing paper may restrict vapour diffusion to the exterior, making the assembly more sensitive to moisture which reaches the wood components in the assembly.

LIMITATIONS ON USE

Good performance can be expected under most circumstances for wood-frame construction in medium exposure conditions. It is not appropriate for use in high exposure conditions. Care is required in placement of strapping since it must not restrict drainage paths (at window jambs). Excessive use of adhered waterproof sheathing membranes at interfaces can restrict drying to the interior and should be avoided.

DOCUMENTED LIMITATIONS

Very few of these assemblies have been constructed in the British Columbia coastal climate zone for a period of time sufficient to assess their long-term performance. However, successful performance of similar assemblies is well documented in other parts of the world. More information is required with respect to drying potential, as well as the structural and curing behaviour of the stucco over varying strapping spacing.

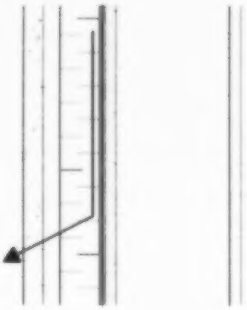
DURABILITY

The assembly is sensitive to moisture which passes the moisture barrier and reaches the exterior sheathing and framing. Therefore, detailing of the interfaces and minimizing the amount of water impacting on the assembly are both significant factors in achieving overall performance and durability.

Since it is anticipated that some water will penetrate past the cladding, the fasteners used to secure the lath, the sheathing paper, and the flashing, must have a service life that is at least as long as that of the stucco.

Stucco assemblies are sensitive to frame shrinkage. Failure to provide appropriate control joints can result in stresses and possibly cracking in the stucco.

ST-4: Stucco–Rainscreen Exterior Insulation Wall Assembly

		Effective RSI (R) *38 X 89*	**Effective RSI (R) *38 X 140***
	AIR FILM	0.03 (0.17)	0.03 (0.17)
	22 mm STUCCO	0.14 (0.80)	0.14 (0.80)
	19 mm CAVITY, GALV. METAL Z-GIRTS	0.16 (0.90)	0.16 (0.90)
	50 mm SEMI RIGID INSULATION	1.46 (8.29)	1.46 (8.29)
	WATERPROOF SHEATHING MEMBRANE (MOISTURE BARRIER)	0.01 (0.05)	0.01 (0.05)
	12 mm WOOD SHEATHING	0.11 (0.60)	0.11 (0.60)
	STUD SPACE	0.18 (1.02)	0.18 (1.02)
	12 mm INTERIOR GYPSUM BOARD	0.08 (0.45)	0.08 (0.45)
	AIR FILM	0.12 (0.68)	0.12 (0.68)
	TOTAL	**2.28 (12.96)**	**2.28 (12.96)**

MOISTURE BARRIER (identified with an arrow on the sketch)
This assembly anticipates control of the majority of exterior moisture at the exterior cladding while recognizing that some incidental moisture will likely migrate beyond the exterior cladding. This moisture is allowed to drain through the cavity formed behind the exterior cladding, and out of the assembly at cross-cavity flashing locations. Further drying of the cavity is facilitated by evaporation through air exchange in the cavity as well as diffusion of a limited amount of moisture through the stucco cladding. The assembly is less sensitive to moisture that reaches the exterior sheathing and framing because there is an increased ability for drying to the interior in the absence of the polyethylene sheet.

AIR BARRIER
The air barrier in this assembly is the adhered waterproof sheathing membrane. It is very easy to ensure continuity over the exterior sheathing. The use of membrane also makes it easy to interface with other wall assemblies, as well as components such as windows and exhaust vents.

VAPOUR BARRIER
The adhered waterproof sheathing membrane provides the vapour barrier function at an ideal location since moisture present on either side of this membrane has an opportunity to drain or dry.

LIMITATIONS ON USE
Good performance can be expected under medium exposure conditions for wood-frame construction. Good performance may also be expected for high exposure conditions if some additional measures are taken to ensure good pressure equalization characteristics for the wall assembly. It is also possible to place additional insulation within the stud space, however some analysis must be undertaken to ensure appropriate control of vapour diffusion, since the vapour barrier is now located within the insulation rather than on the warm side.

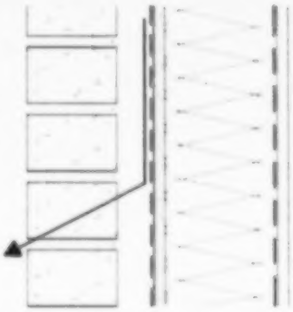
DOCUMENTED LIMITATIONS
Very few of these assemblies have been constructed, so construction detailing has not been fully developed. Although there is limited knowledge regarding long-term performance with wood-frame construction, there is a large amount of information with respect to successful performance of non-combustible assemblies of similar construction.

DURABILITY
Detailing the interfaces and minimizing the amount of water impacting on the assembly are both significant factors in the overall performance and durability of the assembly, despite the assembly's relatively good tolerance to moisture.

Since it is anticipated that some water will penetrate past the cladding, the fasteners used to secure the lath, the sheathing paper, the Z-girts, and the flashing must have a service life that is at least as long as that of the stucco.

Stucco assemblies are sensitive to frame shrinkage. Failure to provide appropriate control joints can result in stresses and possibly cracking in the stucco.

BV-1: Brick Veneer–Rainscreen Wall Assembly

		Effective RSI (R) 38 X 89	Effective RSI (R) 38 X 140
	AIR FILM	0.03 (0.17)	0.03 (0.17)
	BRICK VENEER	0.14 (0.80)	0.14 (0.80)
	25 mm CAVITY	0.16 (0.90)	0.16 (0.90)
	SHEATHING PAPER (MOISTURE BARRIER)	0	0
	12 mm WOOD SHEATHING	0.11 (0.60)	0.11 (0.60)
	INSULATION IN STUD SPACE	1.98 (11.25)	3.26 (18.50)
	6 mil POLYETHYLENE	0	0
	12 mm INTERIOR GYPSUM BOARD	0.08 (0.45)	0.08 (0.45)
	AIR FILM	0.12 (0.68)	0.12 (0.68)
	TOTAL	**2.61 (14.85)**	**3.89 (22.10)**

MOISTURE BARRIER (identified with an arrow on the sketch)

This assembly anticipates control of the majority of the exterior moisture at the exterior cladding while recognizing that some incidental moisture will likely migrate beyond the exterior cladding. This moisture is allowed to drain through the cavity formed behind the exterior cladding, and out of the assembly at cross-cavity flashing locations at the base of the wall. Further drying of the cavity is facilitated by evaporation through air exchange in the cavity, as well as by diffusion of a limited amount of moisture through the brick veneer.

AIR BARRIER

All three air barrier strategies can be used for this wall assembly.

VAPOUR BARRIER

Polyethylene provides the vapour barrier for interior moisture sources. However, it also limits the amount of drying which can occur to the interior, making this wall assembly sensitive to moisture ingress from any source. The use of heavy sheathing papers may restrict vapour diffusion to the exterior.

LIMITATIONS ON USE

Good performance can be expected under most circumstances for wood-frame construction except for high exposure conditions where wetting from the exterior can be significant. Excessive use of adhered waterproof sheathing membranes at interfaces restricts drying to the exterior and should be avoided.

DOCUMENTED LIMITATIONS

These assemblies have been commonly used over a lengthy period of time and they have a good performance history.

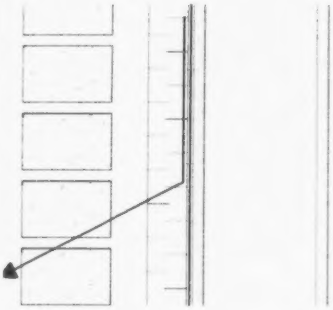
DURABILITY

The assembly is sensitive to moisture which reaches the exterior sheathing and framing. Therefore, detailing of the interfaces and minimizing the amount of water impacting on the assembly are both significant factors in achieving overall performance and durability.

Since it is anticipated that some water will penetrate past the cladding, the masonry ties used to secure the veneer to the wood structure, and the flashing must have a service life that is at least as long as that of the brick veneer.

Brick veneer is sensitive to frame shrinkage. Failure to provide appropriate control joints can result in stresses and possibly cracking in the brick veneer.

BV-2: Brick Veneer–Rainscreen Exterior Insulation Wall Assembly

		Effective RSI (R) 38 X 89	**Effective RSI (R) 38 X 140**
	AIR FILM	0.03 (0.17)	0.03 (0.17)
	BRICK VENEER	0.14 (0.80)	0.14 (0.80)
	25 mm CAVITY	0.16 (0.90)	0.16 (0.90)
	50 mm SEMI RIGID INSULATION	1.46 (8.29)	1.46 (8.29)
	WATERPROOF SHEATHING MEMBRANE (MOISTURE BARRIER)	0.01 (0.05)	0.01 (0.05)
	12 mm WOOD SHEATHING	0.11 (0.60)	0.11 (0.60)
	STUD SPACE	0.18 (1.02)	0.18 (1.02)
	12 mm INTERIOR GYPSUM BOARD	0.08 (0.45)	0.08 (0.45)
	AIR FILM	0.12 (0.68)	0.12 (0.68)
	TOTAL	**2.28 (12.96)**	**2.28 (12.96)**

MOISTURE BARRIER (identified with an arrow on the sketch)

This assembly anticipates control of the majority of the exterior moisture at the exterior cladding while recognizing that some incidental moisture will likely migrate beyond the exterior cladding. This moisture is allowed to drain through the cavity formed behind the exterior cladding, and is allowed to drain out of the assembly at cross-cavity flashing locations at the base of the wall. Further drying of the cavity is facilitated by evaporation through air exchange in the cavity as well as diffusion of a limited amount of moisture through the brick veneer. The assembly is less sensitive to moisture that reaches the exterior sheathing and framing because there is an increased ability for drying to the interior in the absence of the polyethylene sheet.

AIR BARRIER

The air barrier in this assembly is the adhered waterproof sheathing membrane. It is very easy to ensure continuity over the exterior sheathing. The use of membrane also makes it easy to interface with other wall assemblies, as well as components such as windows and exhaust vents.

VAPOUR BARRIER

The adhered waterproof sheathing membrane provides the vapour barrier function at an ideal location since moisture present on either side of this membrane has an opportunity to drain or dry.

LIMITATIONS ON USE

Good performance can be expected under medium exposure conditions for wood-frame construction. Good performance may also be provided under high exposure conditions if some additional measures are taken to ensure good pressure equalization characteristics for the wall assembly. It is also possible to place additional insulation within the stud space, however some analysis must be undertaken to ensure appropriate control of vapour diffusion, since the vapour barrier is now located within the insulation rather than on the warm side.

DOCUMENTED LIMITATIONS

Although there is limited knowledge regarding long-term performance of this assembly, there is a large amount of information with respect to successful performance of non-combustible assemblies of similar construction.

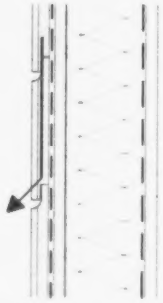
DURABILITY

Detailing the interfaces and minimizing the amount of water impacting on the assembly are both significant factors in the overall performance and durability of the assembly, despite the assembly's relatively good tolerance to moisture.

Since it is anticipated that some water will penetrate past the cladding, the masonry ties used to secure the veneer to the wood structure, and the flashing must have a service life that is at least as long as that of the brick veneer.

Brick veneer is sensitive to frame shrinkage. Failure to provide appropriate control joints can result in stresses and possibly cracking of the brick veneer.

HS-1: Horizontal Siding–Concealed Barrier Wall Assembly

		Effective RSI (R) 38 X 89	**Effective RSI (R) 38 X 140**
	AIR FILM	0.03 (0.17)	0.03 (0.17)
	19 mm HORIZONTAL SIDING (WOOD)	0.14 (0.80)	0.14 (0.80)
	SHEATHING PAPER (MOISTURE BARRIER)	0	0
	12 mm WOOD SHEATHING	0.11 (0.60)	0.11 (0.60)
	INSULATION IN STUD SPACE	1.98 (11.25)	3.26 (18.50)
	6 mil POLYETHYLENE	0	0
	12 mm INTERIOR GYPSUM BOARD	0.08 (0.45)	0.08 (0.45)
	AIR FILM	0.12 (0.68)	0.12 (0.68)
	TOTAL	**2.46 (13.95)**	**3.73 (21.20)**

MOISTURE BARRIER (identified with an arrow on the sketch)
This assembly anticipates control of the majority of the exterior moisture at the exterior cladding while recognizing that a minor amount of incidental moisture will likely migrate beyond the exterior cladding. This moisture is allowed to drain through a series of small interconnected cavities formed between the siding and building paper. The size and effectiveness of these cavities varies significantly from one type of horizontal siding product to another. The assembly incorporates flashing to direct this incidental moisture out of the assembly at the base of the wall.

AIR BARRIER
All three air barrier strategies can be used for this wall assembly.

VAPOUR BARRIER
Polyethylene provides the vapour barrier for interior moisture sources. However, it limits the amount of drying which can occur to the interior, thus making this wall assembly sensitive to moisture ingress from any source. The use of heavy sheathing papers, some coatings on wood siding, or the inherent vapour impermeable nature of vinyl and aluminum, may restrict vapour diffusion to the exterior, further contributing to the sensitive nature of the assembly.

LIMITATIONS ON USE
The incidental moisture drainage cavities are very dependent on the actual siding materials used. The beneficial effect of the larger cavity and better drainage characteristics of vinyl or aluminum siding is offset by the inherently larger number of joints in these types of siding, which are potential sources of water penetration past the cladding. Good performance can be expected only under low exposure conditions.

DOCUMENTED LIMITATIONS
These assemblies have a recent history of poor performance in medium exposure conditions and this performance has been well documented. There is less information available regarding their performance when details are well designed and constructed or exposure conditions are reduced through the use of overhangs.

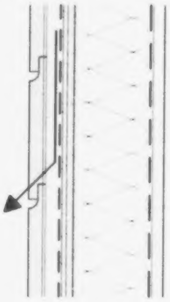
DURABILITY
The assembly is sensitive to moisture that reaches the exterior sheathing and framing and therefore detailing the interfaces and minimizing the amount of water impacting on the assembly are both significant factors in the overall performance and durability of the assembly.

Since it is anticipated that some water will penetrate past the cladding, the fasteners used to secure the cladding, and the flashing must have a service life that is at least as long as that of the cladding.

Wood siding should be back primed to improve the durability of the wood and reduce the effect of resins on some types of sheathing paper.

Drainage holes in vinyl must be large enough to overcome capillary forces. Fasteners must be used as recommended by the manufacturers to accommodate frame shrinkage and thermal expansion and contraction.

HS-2: Horizontal Siding–Rainscreen Wall Assembly



	Effective RSI (R) 38 X 89	Effective RSI (R) 38 X 140
AIR FILM	0.03 (0.17)	0.03 (0.17)
19 mm HORIZONTAL SIDING (WOOD)	0.14 (0.80)	0.14 (0.80)
19 mm CAVITY, P.T. WOOD STRAPPING	0.16 (0.90)	0.16 (0.90)
SHEATHING PAPER (MOISTURE BARRIER)	0	0
12 mm WOOD SHEATHING	0.11 (0.60)	0.11 (0.60)
INSULATION IN STUD SPACE	1.98 (11.25)	3.26 (18.50)
6 mil POLYETHYLENE	0	0
12 mm INTERIOR GYPSUM BOARD	0.08 (0.45)	0.08 (0.45)
AIR FILM	0.12 (0.68)	0.12 (0.68)
TOTAL	**2.61 (14.85)**	**3.89 (22.10)**

MOISTURE BARRIER (identified with an arrow on the sketch)

This assembly anticipates control of the majority of exterior moisture at the exterior cladding while recognizing that some incidental moisture will likely migrate beyond the exterior cladding. This moisture is allowed to drain through the cavity formed behind the exterior cladding, and out of the assembly at cross-cavity flashing locations. Further drying of the cavity is facilitated by evaporation through air exchange in the cavity as well as diffusion of a limited amount of moisture through the siding.

AIR BARRIER

All three air barrier strategies can be used for this wall assembly.

VAPOUR BARRIER

Polyethylene provides the vapour barrier for interior moisture sources. However, it also limits the amount of drying which can occur to the interior, thus making this wall assembly sensitive to moisture ingress from any source. The use of heavy sheathing papers, and some coatings on wood siding, or the inherent vapour impermeable nature of vinyl and aluminum, may restrict vapour diffusion to the exterior, further contributing to the sensitive nature of the assembly.

LIMITATIONS ON USE

Good performance can be expected under most circumstances for wood-frame construction, except for high exposure conditions where wetting from the exterior can be significant. Care is required in placement of strapping since it must not restrict drainage paths at window jambs. Excessive use of adhered waterproof sheathing membranes at interfaces restricts drying to the exterior and should be avoided.

DOCUMENTED LIMITATIONS

These assemblies have been commonly used over a lengthy period of time and they have a good performance history. Some manufacturers have expressed concern regarding the use of vinyl siding over strapping at 400 mm spacing. The lack of stiffness in some siding products may require closer spacing to provide adequate structural support.

DURABILITY

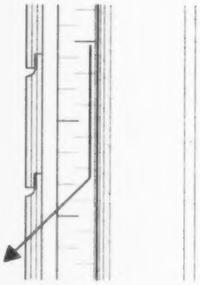
The assembly is sensitive to moisture which reaches the exterior sheathing and framing and therefore detailing the interfaces and minimizing the amount of water impacting on the assembly are both significant factors in the overall performance and durability of the assembly.

Since it is anticipated that some water will penetrate past the cladding, the fasteners used to secure the cladding, and the flashing must have a service life that is at least as long as that of the cladding.

Wood siding should be back primed to improve durability of the wood.

Drainage holes in vinyl must be large enough to overcome capillary forces. Fasteners must be used as recommended by the manufacturers to accommodate frame shrinkage and thermal expansion and contraction.

HS-3: Horizontal Siding–Rainscreen Exterior Insulation Wall Assembly

		Effective RSI (R) 38 X 89	Effective RSI (R) 38 X 140
	AIR FILM	0.03 (0.17)	0.03 (0.17)
	19 mm HORIZONTAL SIDING (WOOD)	0.14 (0.80)	0.14 (0.80)
	19 mm CAVITY, P.T. WOOD STRAPPING	0.16 (0.90)	0.16 (0.90)
	50 mm SEMI RIGID INSULATION	1.46 (8.29)	1.46 (8.29)
	WATERPROOF SHEATHING MEMBRANE (MOISTURE BARRIER)	0.01 (0.05)	0.01 (0.05)
	12 mm WOOD SHEATHING	0.11 (0.60)	0.11 (0.60)
	STUD SPACE	0.18 (1.02)	0.18 (1.02)
	12 mm INTERIOR GYPSUM BOARD	0.08 (0.45)	0.08 (0.45)
	AIR FILM	0.12 (0.68)	0.12 (0.68)
	TOTAL	**2.28 (12.96)**	**2.28 (12.96)**

MOISTURE BARRIER (identified with an arrow on the sketch)

This assembly anticipates control of the majority of the exterior moisture at the exterior cladding while recognizing that some incidental moisture will likely migrate beyond the exterior cladding. This moisture is allowed to drain through the cavity formed behind the exterior cladding, and out of the assembly at cross-cavity flashing locations. Further drying of the cavity is facilitated by evaporation through air exchange in the cavity as well as diffusion of a limited amount of moisture through the cladding. The assembly is less sensitive to moisture that reaches the exterior sheathing and framing because there is an increased ability for drying to the interior in the absence of the polyethylene sheet.

AIR BARRIER

The air barrier in this assembly is the adhered waterproof sheathing membrane. It is very easy to ensure continuity over the exterior sheathing. The use of membrane also makes it easy to interface with other wall assemblies, as well as components such as windows and exhaust vents.

VAPOUR BARRIER

The adhered waterproof sheathing membrane provides the vapour barrier function at an ideal location since moisture present on either side of this membrane has an opportunity to drain or dry.

LIMITATIONS ON USE

Good performance can be expected under medium exposure conditions for wood-frame construction. Good performance may also be provided for high exposure conditions with some additional measures taken to ensure good pressure equalization characteristics for the wall assembly. It is also possible to place additional insulation within the stud space, however some analysis must be undertaken to ensure appropriate control of vapour diffusion, since the vapour barrier is now located within the insulation rather than on the warm side.

DOCUMENTED LIMITATIONS

Very few of these assemblies have been constructed, so construction detailing has not been fully developed. Although there is limited knowledge regarding long-term performance, there is a large amount of information with respect to successful performance of non-combustible assemblies of similar construction.

DURABILITY

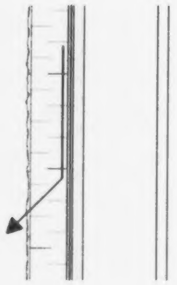
Detailing the interfaces and minimizing the amount of water impacting on the assembly are both significant factors in the overall performance and durability of the assembly, despite the assembly's relatively good tolerance to moisture.

Since it is anticipated that some water will penetrate past the cladding, the fasteners used to secure the cladding, and the flashing must have a service life that is at least as long as that of the cladding.

Wood siding should be back primed to improve durability of the wood.

Drainage holes in vinyl must be large enough to overcome capillary forces. Fasteners must be used as recommended by the manufacturers to accommodate frame shrinkage and thermal expansion and contraction.

EIFS-1: Exterior Insulation Finish System Rainscreen Wall Assembly

		Effective RSI (R) 50 mm	**Effective RSI (R) 75 mm**
	AIR FILM	0.03 (0.17)	0.03 (0.17)
	LAMINA	0.05 (0.30)	0.05 (0.30)
	EPS INSULATION (Incorporating drainage channels, mechanically fastened)	1.36 (7.70)	2.03 (11.55)
	WATERPROOF SHEATHING MEMBRANE (MOISTURE BARRIER)	0.01 (0.05)	0.01 (0.05)
	12 mm WOOD SHEATHING	0.11 (0.60)	0.11 (0.60)
	STUD SPACE	0.18 (1.02)	0.18 (1.02)
	12 mm INTERIOR GYPSUM BOARD	0.08 (0.45)	0.08 (0.45)
	AIR FILM	0.12 (0.68)	0.12 (0.68)
	TOTAL	**1.93 (10.97)**	**2.61 (14.82)**

MOISTURE BARRIER (identified with an arrow on the sketch)

This assembly anticipates control of the majority of the exterior moisture at the exterior cladding while recognizing that some incidental moisture will likely migrate beyond the exterior cladding. The primary moisture barrier is the adhered waterproof sheathing membrane. Moisture is allowed to drain through the cavity formed behind the exterior cladding, and out of the assembly at cross-cavity flashing locations. The cavity is created through the introduction of channels in the back side of the insulation or by placing the insulation over a lattice drainage mat material. The assembly is less sensitive to moisture that reaches the exterior sheathing and framing because there is an increased ability for drying to the interior in the absence of the polyethylene sheet.

AIR BARRIER

The air barrier in this assembly is the adhered waterproof sheathing membrane. It is very easy to ensure continuity over the exterior sheathing. The use of membrane also makes it easy to interface with other wall assemblies, as well as components such as windows and exhaust vents.

VAPOUR BARRIER

The adhered waterproof sheathing membrane provides the vapour barrier function at an ideal location since moisture present on either side of this membrane has an opportunity to drain or dry.

LIMITATIONS ON USE

Good performance can be expected under medium exposure conditions for wood-frame construction. The thin lamina is susceptible to damage due to impact. Therefore, in areas where impact is likely to occur, it is recommended that a heavy-duty mesh be used to improve resistance to impact. The implications of impact damage (penetration of the lamina) on the water management characteristics for this wall assembly are not significant since the moisture barrier is the adhered waterproof sheathing membrane and is protected from damage.

DOCUMENTED LIMITATIONS

Very few of these assemblies have been in service for a period of time sufficient to allow for the assessment of long-term performance. However, the behaviour of individual components and materials is well known, and the arrangement of materials in this assembly makes it relatively insensitive to moisture sources.

DURABILITY

Detailing the interfaces and minimizing the amount of water impacting on the assembly are both significant factors in the overall performance and durability of the assembly, despite the assembly's relatively good tolerance to moisture.

Resistance to impact damage is a limitation of this cladding. However, acceptable performance can be provided for most in-service environments through the use of heavy-duty mesh. The mechanically fastened lamina and the use of an adhered waterproof sheathing membrane results in the assembly being able to accommodate normal wood-frame shrinkage and eliminates dependence on adhesives for attachment.

ROOF ASSEMBLIES

Roof assemblies, in this Guide, include pitched roof assemblies, a variety of low slope roof assemblies and some pedestrian traffic areas.

If a pedestrian traffic area is located over a living space and is insulated, it is considered a roof assembly. Decks and walkways over living spaces not only act as roofs but they are subjected to the additional loads of pedestrian traffic since they are used as exterior living space. This dictates a more durable combination of water management strategy and wearing surface for these assemblies.

Balcony and walkway pedestrian areas that are outside the building perimeter and are not roofs have less risk of damage should leaks occur, and generally have greater capability for drying. Therefore, different combinations of water management strategies and wearing surfaces can be used for these assemblies and still achieve acceptable water management performance and durability. Balconies and walkways which are exterior to the building are discussed on Balcony / Walkway Assemblies, page 5-27.

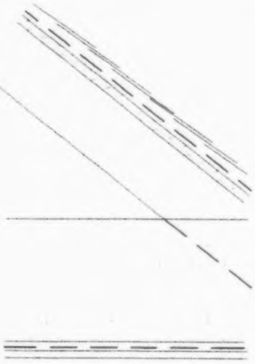
By their nature, roof assemblies are exposed to exterior moisture sources. This distinguishes them from wall assemblies where it is possible to design to restrict wetting. Since it is guaranteed that roofs will get wet and that if a leak occurs the wood structure beneath will get wet continuously, all roof assemblies are sensitive to exterior moisture control and failures in the moisture barrier.

However, three of the assemblies shown are particularly sensitive to moisture from any source. These roof assemblies have the insulation located within the roof joist space and rely on venting through relatively small or confined spaces for their drying capabilities: Water Shedding–Vented Cathedral Assembly (WS-2), Waterproof Membrane–Vented Assembly (WM-1) and Pedestrian Surface–Vented Assembly (PS-1). The geometry of many roofs may sufficiently restrict air movement in the vent space so that effective ventilation is not possible. In addition, the potential for drying is further limited by the presence of the polyethylene above the ceiling. Should a roof leak occur in one of these assemblies, the water can remain unnoticed within the framing of the assembly and will often lead to decay of the roof assembly before the leak is noted. In addition, Waterproof Membrane–Vented Assembly (WM-1) and Pedestrian Surface–Vented Assembly (PS-1) do not have gravity working in their favour to help drain water out of the assembly. Therefore, these three assemblies are very sensitive to moisture and require a more rigorous inspection and maintenance program.

Eight different roof assemblies are presented:

- Roof WS-1: Water Shedding–Vented Loft Assembly
- Roof WS-2: Water Shedding–Vented Cathedral Assembly
- Roof WS-3: Water Shedding–Rainscreen Roof Assembly
- Roof WM-1: Waterproof Membrane–Vented Assembly
- Roof WM-2: Waterproof Membrane–Conventional Assembly
- Roof WM-3: Waterproof Membrane–Protected Assembly
- Roof PS-1: Pedestrian Surface–Vented Assembly
- Roof PS-2: Pedestrian Surface–Exterior Insulation Assembly

WS-1: Water Shedding–Vented Loft Assembly

		Effective RSI (R)
	AIR FILM	0.03 (0.17)
	WATER SHEDDING ROOF SYSTEM (MOISTURE BARRIER)	0
	ROOF SHEATHING	0
	ROOF FRAMING	0
	VENTED AIRSPACE (ATTIC)	0
	FIBREGLASS BATT INSULATION	6.13 (34.80)
	6 mil POLYETHYLENE	0
	12 mm INTERIOR GYPSUM BOARD	0.08 (0.45)
	AIR FILM	0.11 (0.61)
	TOTAL	**6.35 (36.03)**

MOISTURE BARRIER

This assembly sheds all exterior moisture by gravity drainage over shingled materials. It does not anticipate the presence of exterior moisture within the vented roof space and is therefore a face seal assembly. The assembly is somewhat sensitive to exterior moisture that penetrates at a roof leak location since water can sit on top of polyethylene and saturate the roof framing prior to being detected. The good venting capability of this assembly will help to dry the assembly in the event of a minor leak.

AIR BARRIER

Both the sealed polyethylene and airtight drywall approaches can be used as air barrier strategies in this assembly.

VAPOUR BARRIER

Polyethylene provides the vapour barrier for control of interior moisture sources.

LIMITATIONS ON USE

Good performance can be expected under all circumstances for low-rise construction. Detailing the flashing, gutters, and downspouts is important for the successful performance of this assembly. The performance of the assembly also depends on a combination of adequate venting and airtightness of the ceiling.

DOCUMENTED LIMITATIONS

This type of roof assembly is very common and has a history of good performance.

DURABILITY

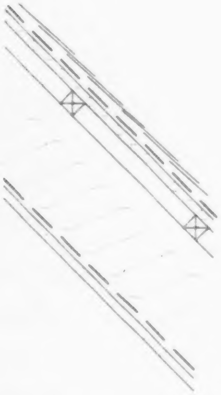
The assembly is sensitive to moisture that reaches the roof sheathing and framing.

Detailing of the interfaces and penetrations is a significant factor in the overall performance and durability of the assembly.

Maintenance of these systems is minimal aside from clearing gutters and securing dislodged shingles.

The type of water shedding roof system will usually dictate the life expectancy of the assembly.

WS-2: Water Shedding–Vented Cathedral Assembly

		Effective RSI (R)
	AIR FILM	0.03 (0.17)
	WATER SHEDDING ROOF SYSTEM (MOISTURE BARRIER)	0
	ROOF SHEATHING	0
	AIR SPACE IN CROSS STRAPPING	0
	INSULATION IN ROOF RAFTERS	4.75 (27.00)
	6 mil POLYETHYLENE	0
	12 mm INTERIOR GYPSUM BOARD	0.08 (0.45)
	AIR FILM	0.11 (0.61)
	TOTAL	**4.97 (28.24)**

MOISTURE BARRIER

This assembly sheds all exterior moisture by gravity drainage over shingled materials. It does not anticipate the presence of exterior moisture within the vented roof space and is therefore a face seal assembly. The assembly is somewhat sensitive to exterior moisture that penetrates at a roof leak location since water can run on top of the polyethylene and saturate the roof framing prior to being detected. The venting capability of this assembly will help to dry the assembly in the event of a minor leak.

AIR BARRIER

Both the sealed polyethylene and airtight drywall approaches can be used as air barrier strategies in this assembly.

VAPOUR BARRIER

Polyethylene provides the vapour barrier for control of interior moisture sources.

LIMITATIONS ON USE

Good performance can be expected under most circumstances for low-rise construction. However, it is common to find decayed wood when these roof assemblies are replaced due to the presence of moisture in the assembly, either from an undetected roof leak or inadequate ventilation. In some cases, the roof geometry makes it difficult to ensure good flow-through ventilation. Geometry, detailing and an airtight ceiling are therefore key issues to ensure the successful performance of these assemblies.

DOCUMENTED LIMITATIONS

Many of these assemblies are in service and have provided good performance, however many have not, primarily due to the issues discussed above under Limitations on Use.

DURABILITY

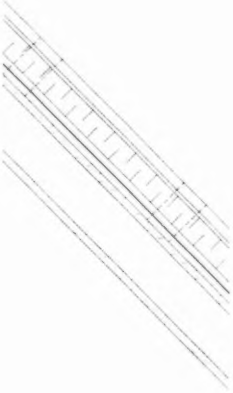
The assembly is sensitive to moisture that reaches the roof sheathing and framing.

Detailing of the interfaces and penetrations is a significant factor in the overall performance and durability of the assembly.

Maintenance of these systems is minimal aside from clearing gutters and securing dislodged shingles.

The type of water shedding roof system will usually dictate the life expectancy of the assembly.

WS-3: Water Shedding–Rainscreen Roof Assembly

		Effective RSI (R)
	AIR FILM	0.03 (0.17)
	METAL ROOFING	0
	AIR SPACE	0
	INSULATION AND STRAPPING	4.44 (25.20)
	WATERPROOF ROOF MEMBRANE SYSTEM (MOISTURE BARRIER)	0.01 (0.05)
	16 mm ROOF SHEATHING	0.14 (0.80)
	ROOF RAFTERS	0.03 (0.15)
	12 mm INTERIOR GYPSUM BOARD	0.08 (0.45)
	AIR FILM	0.11 (0.62)
	TOTAL	**4.83 (27.44)**

MOISTURE BARRIER

This assembly anticipates control of the majority of exterior moisture at the exterior cladding while recognizing that some incidental moisture will likely migrate beyond the exterior cladding. This moisture is allowed to drain through the cavity formed behind the exterior cladding on the roof membrane, and out of the assembly at the base of the roof. Further drying is facilitated by evaporation through venting in the cavity.

AIR BARRIER

Both the airtight drywall approach and exterior air barrier approach can be used for this roof assembly. The exterior air barrier approach is very easy to implement using the waterproof roof membrane system.

VAPOUR BARRIER

The adhered waterproof sheathing membrane provides the vapour barrier function at an ideal location since moisture present on either side of this membrane has an opportunity to drain or dry.

LIMITATIONS ON USE

Good performance can be expected under all circumstances for low-rise construction. Detailing the flashing, metal roofing joints, and gutters and downspouts is important for the successful performance of this assembly.

DOCUMENTED LIMITATIONS

This type of roof assembly is common and has a history of good performance.

DURABILITY

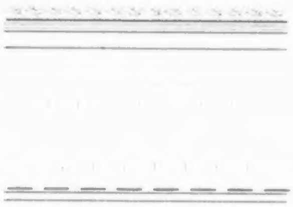
The assembly is sensitive to moisture that reaches the roof sheathing and framing.

Detailing of the interfaces and penetrations is a significant factor in the overall performance and durability of the assembly.

Maintenance of these systems is minimal aside from clearing gutters and securing dislodged shingles.

The type of water shedding roof system will usually dictate the life expectancy of the assembly.

WM-1: Waterproof Membrane–Vented Assembly

		Effective RSI (R)
	AIR FILM	0.03 (0.17)
	WATERPROOF ROOF MEMBRANE SYSTEM (MOISTURE BARRIER)	0
	ROOF SHEATHING	0
	AIR SPACE IN CROSS STRAPPING	0
	INSULATION IN ROOF JOINTS	4.75 (27.00)
	6 mil POLYETHYLENE	0
	12 mm INTERIOR GYPSUM BOARD	0.08 (0.45)
	AIR FILM	0.11 (0.61)
	TOTAL	**4.97 (28.23)**

MOISTURE BARRIER

This assembly anticipates the control of all of the moisture at the waterproof membrane. It does not anticipate the presence of exterior moisture within the vented roof space and is therefore a face seal assembly. The assembly is very sensitive to exterior moisture that penetrates at a roof leak location since water can sit on top of the polyethylene and saturate the roof framing prior to being detected. The venting capability of this assembly will help to dry the assembly in the event of a minor leak.

AIR BARRIER

Both the sealed polyethylene and airtight drywall approaches can be used in this assembly.

VAPOUR BARRIER

Polyethylene provides the vapour barrier for control of interior moisture sources.

LIMITATIONS ON USE

Good performance can be expected under most circumstances for low-rise construction. However, it is common to find decayed wood when these roof assemblies are replaced due to the presence of moisture in the assembly, either from an undetected roof leak or inadequate ventilation. In some cases the roof geometry makes it difficult to ensure good flow-through ventilation. Geometry, detailing and an airtight ceiling are therefore key issues to ensure successful performance of these assemblies. Insulation and ventilation requirements may dictate joist sizing and interfere with mechanical and electrical services.

DOCUMENTED LIMITATIONS

Many of these assemblies are in service and have provided good performance, however many have not, primarily due to the issues discussed above under Limitations on Use.

DURABILITY

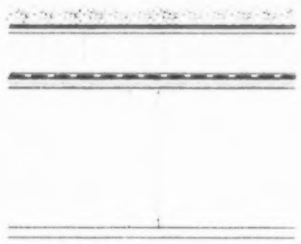
The assembly is sensitive to moisture that reaches the roof sheathing and framing and therefore detailing of interfaces and membrane material type are both significant factors in the overall performance and durability of the assembly.

Draining the roof is fundamental to its durable performance, and therefore the location and sizing of drains, and providing a positive slope to the drains are critical design features.

The near horizontal and exposed nature of the waterproof roof membrane system may contribute to a shortened life expectancy for this assembly due to a variety of factors including thermal cycling, resistance to ultra-violet light, pedestrian traffic, water ponding and freezing. Maintenance is therefore critical for durable performance of the assembly.

The roof membrane is applied directly over the roof sheathing and is therefore sensitive to relative movements in the sheathing. Proper framing techniques and allowance for movement in the structure and roof membrane are therefore important considerations.

WM-2: Waterproof Membrane–Conventional Assembly

		Effective RSI (R)
	AIR FILM	0.03 (0.17)
	WATERPROOF ROOF MEMBRANE SYSTEM (MOISTURE BARRIER)	0.06 (0.33)
	12 mm FIBREBOARD	0.26 (1.47)
	2 LAYERS 50 mm POLYISOCYANURATE	3.52 (20.00)
	2 LAYERS ASPHALT LAMINATE PAPER	0.14 (0.77)
	16 mm ROOF SHEATHING	0.01 (0.06)
	ROOF JOISTS	0.03 (0.15)
	12 mm INTERIOR GYPSUM BOARD	0.08 (0.45)
	AIR FILM	0.11 (0.61)
	TOTAL	**5.64 (32.01)**

MOISTURE BARRIER

This assembly anticipates the control of all of the moisture at the waterproof membrane. It does not anticipate the presence of exterior moisture within the insulation or wood framing and is therefore a face seal assembly. The assembly is sensitive to exterior moisture which penetrates at a roof leak location since water can migrate past the insulation and asphalt laminate paper to the wood framing and interior.

AIR BARRIER

Both the airtight drywall approach and exterior air barrier approach can be used for this roof assembly. The exterior air barrier approach is very easy to implement using either the two layers of asphalt laminate paper or the waterproof roof membrane system.

VAPOUR BARRIER

Two layers of asphalt laminate paper provide the vapour barrier for control of interior moisture sources.

LIMITATIONS ON USE

The continuity of the roof membrane system and positive drainage are critical in this assembly and essential for good performance.

DOCUMENTED LIMITATIONS

Many of these assemblies are in service and have provided good performance.

DURABILITY

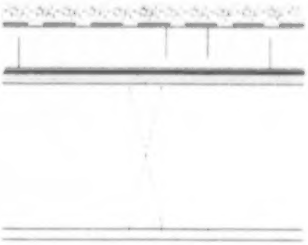
The assembly is sensitive to moisture that reaches the roof sheathing and framing and therefore both detailing the interfaces and using waterproof roof membrane materials are significant factors in the overall performance and durability of the assembly.

Draining the roof is fundamental to its durable performance, and therefore the location and sizing of drains, and the provision of positive slope to the drains are critical design features.

The near horizontal and exposed nature of the waterproof roof membrane system may contribute to a shortened life expectancy for this assembly due to a variety of factors including thermal cycling, resistance to ultra-violet light, pedestrian traffic, water ponding and freezing. Maintenance is therefore critical for durable performance of the assembly.

Leaks in these assemblies are noticed quickly and therefore damage resulting from leaks can be minimized.

WM-3: Waterproof Membrane–Protected Assembly

		Effective RSI (R)
	AIR FILM	0.03 (0.17)
	AGGREGATE BALLAST	0
	FILTER FABRIC	0
	2 LAYERS 50 mm EXTRUDED POLYSTYRENE	3.52 (20.00)
	WATERPROOF ROOF MEMBRANE SYSTEM (MOISTURE BARRIER)	0.06 (0.33)
	16 mm ROOF SHEATHING	0.14 (0.77)
	ROOF JOISTS	0.03 (0.15)
	12 mm INTERIOR GYPSUM BOARD	0.08 (0.45)
	AIR FILM	0.11 (0.61)
	TOTAL	**3.96 (22.48)**

MOISTURE BARRIER

This assembly anticipates the control of the majority of the exterior moisture at the waterproof roof membrane system with some amounts of water shed to the drainage system by the ballast and insulation. The assembly is sensitive to exterior moisture that penetrates at a roof leak location to the wood framing and interior.

AIR BARRIER

Both the airtight drywall approach and exterior air barrier approach can be used for this roof assembly. The exterior air barrier approach is very easy to implement using the waterproof roof membrane system.

VAPOUR BARRIER

The waterproof roof membrane system provides the vapour barrier function at an ideal location since moisture present on either side of this membrane has an opportunity to drain or dry.

LIMITATIONS ON USE

The continuity of the roof membrane system is critical in this assembly and essential for good performance. The additional ballast load means that the roof assembly must have a greater structural capacity.

DOCUMENTED LIMITATIONS

This type of roof assembly is common and has a history of good performance. Detailing and positive drainage are important for successful performance of this assembly.

DURABILITY

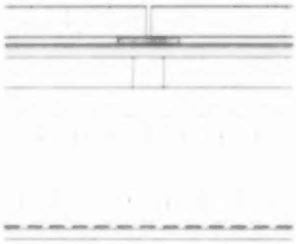
The assembly is difficult to maintain and sensitive to moisture that reaches the wood sheathing and framing and therefore both detailing the interfaces and waterproof roof membrane type are significant factors in the overall performance and durability of the assembly.

Draining the roof is fundamental to its durable performance, and therefore the location and sizing of drains, and providing positive slope to the drains are critical design features.

The waterproof membrane roof system in this assembly is protected from loading, including thermal cycling, is resistant to ultra-violet light and pedestrian traffic, and therefore provides a relatively durable assembly, with less maintenance requirements than exposed membrane systems.

The roof membrane is applied directly over the roof sheathing and is therefore sensitive to relative movements in the sheathing. Proper framing techniques and allowance for movement in the structure and roof membrane are therefore important considerations.

PS-1: Pedestrian Surface–Vented Assembly

		Effective RSI (R)
	AIR FILM	0.03 (0.17)
	DECK SURFACE	0
	PEDESTALS OR DRAINAGE COMPOSITE	0
	WATERPROOF ROOF MEMBRANE SYSTEM (MOISTURE BARRIER)	0
	ROOF SHEATHING	0
	AIR SPACE IN CROSS STRAPPING	0
	INSULATION IN ROOF JOIST	4.75 (27.00)
	6 mil POLYETHYLENE	0
	12 mm INTERIOR GYPSUM BOARD	0.08 (0.45)
	AIR FILM	0.11 (0.61)
	TOTAL	**4.97 (28.23)**

MOISTURE BARRIER

This assembly anticipates the control of all of the moisture at the waterproof membrane. It does not anticipate the presence of exterior moisture within the vented roof space and is therefore a face seal assembly. The assembly is very sensitive to exterior moisture that penetrates at a roof leak location since water can sit on top of the polyethylene and saturate the roof framing prior to being detected. The venting capability of this assembly will help to dry the assembly in the event of a minor leak.

AIR BARRIER

Both the sealed polyethylene and airtight drywall approaches can be used in this assembly.

VAPOUR BARRIER

Polyethylene provides the vapour barrier for control of interior moisture sources.

LIMITATIONS ON USE

Good performance can be expected under most circumstances for low-rise construction. It is common to find decayed wood when these roof assemblies are replaced due to the presence of moisture in the assembly, either from an undetected roof leak or inadequate ventilation. In some cases, the roof geometry makes it difficult to ensure good flow-through ventilation. Geometry, detailing and an airtight ceiling are therefore key issues to ensure the successful performance of these assemblies. Insulation and ventilation requirements may dictate joist sizing and interfere with mechanical and electrical services.

DOCUMENTED LIMITATIONS

Many of these assemblies are in service and have provided good performance, but many have not, primarily due to the issues discussed above under Limitations on Use.

DURABILITY

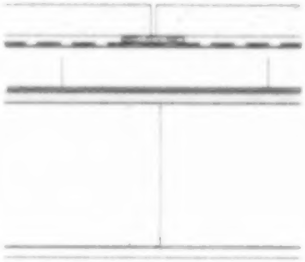
The assembly is difficult to maintain and sensitive to moisture that reaches the roof sheathing and framing, and therefore detailing of interfaces and the choice of membrane material type are significant factors in the overall performance and durability of the assembly.

Draining the roof is fundamental to its durable performance, and therefore the location and sizing of drains, and providing positive slope to the drains are critical design features.

The roof membrane is applied directly over the roof sheathing and is therefore sensitive to relative movements in the sheathing. Proper framing techniques and allowance for movement in the structure and roof membrane are therefore important considerations.

Although the waterproof roof membrane system is somewhat protected by the deck surface, it may still be subject to loading (including thermal cycling and water ponding) which may result in a shortened life expectancy.

PS-2: Pedestrian Surface–Exterior Insulation Assembly

		Effective RSI (R)
	AIR FILM	0.03 (0.17)
	DECK SURFACE	0
	PEDESTALS OR DRAINAGE COMPOSITE	0
	FILTER FABRIC	0
	2 LAYERS 50 mm EXTRUDED POLYSTYRENE	3.52 (20.00)
	WATERPROOF ROOF MEMBRANE SYSTEM (MOISTURE BARRIER)	0.06 (0.33)
	16 mm ROOF SHEATHING	0.14 (0.77)
	ROOF JOISTS	0.03 (0.15)
	12 mm INTERIOR GYPSUM BOARD	0.08 (0.45)
	AIR FILM	0.11 (0.61)
	TOTAL	**3.96 (22.48)**

MOISTURE BARRIER

This assembly anticipates the control of the majority of the exterior moisture at the waterproof roof membrane system with some amounts of water shed to the drainage system by the ballast and insulation. The assembly is sensitive to exterior moisture that penetrates at a roof leak location to the wood framing and interior gypsum board.

AIR BARRIER

Both the airtight drywall approach and exterior air barrier approach can be used for this roof assembly. The exterior air barrier approach is very easy to implement using the waterproof roof membrane system.

VAPOUR BARRIER

The waterproof roof membrane system provides the vapour barrier function at an ideal location since moisture present on either side of this membrane has an opportunity to drain or dry.

LIMITATIONS ON USE

The continuity of the roof membrane system is critical in this assembly and essential for good performance.

DOCUMENTED LIMITATIONS

This type of roof assembly is very common and has a history of good performance.

DURABILITY

The assembly is difficult to maintain and sensitive to moisture that reaches the roof sheathing and framing and therefore both detailing the interfaces and the selection of the membrane material type are significant factors in the overall performance and durability of the assembly.

Draining the roof is fundamental to its durable performance, and therefore the location and sizing of drains, and providing positive slope to the drains are critical design features.

In this inverted assembly, the waterproof roof membrane system is protected from loading, including thermal cycling, resistance to ultra-violet light and pedestrian traffic, and therefore provides a relatively durable assembly.

The roof membrane is applied directly over the roof sheathing and is therefore sensitive to relative movements in the sheathing. Proper framing techniques and allowance for movement in the structure and roof membrane are therefore important considerations.

Leaks in these assemblies are noticed quickly and therefore damage resulting from leaks can be minimized.

BALCONY / WALKWAY ASSEMBLIES

Balcony and walkway surfaces are not located over living spaces, are not insulated, and do not require a vapour barrier. However, they must manage exterior moisture sources. Although balconies and walkways are exterior to the environmental separator, they do frame into, and provide protection for, the rim joist area of the wall (environmental separator) and are therefore key elements in the overall moisture management system.

Two different balcony and walkway assemblies are presented:

BW-1: Balcony / Walkway–Exposed Membrane Assembly
BW-2: Balcony / Walkway–Protected Membrane Assembly

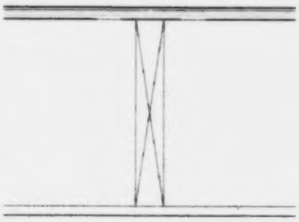
The *1992 British Columbia Building Code* required that all exterior balconies be constructed with the same fire resistance rating as either the adjacent floor assembly or the adjacent exposed building face (whichever was more restrictive). For multi-family residential buildings, this requirement resulted in continuous gypsum board soffits with no opportunity for soffit venting of the concealed balcony joist space. Venting of such spaces had to be accomplished with some intricate detailing of the fascia or guardrail, and such details commonly resulted in inadequate cross ventilation of the joist space.

The *1998 British Columbia Building Code* has deleted the requirement for fire rating of exterior balconies. This means that vented soffits are now permitted in exterior balconies and thus improved ventilation and drying of concealed joist spaces can be achieved.

It should also be noted that Clause 3.2.2.12 of the *1998 British Columbia Building Code* requires that exterior passageways that are part of a means of egress must have the fire resistance rating to match that of a mezzanine within the building.

Both balcony, and exterior passageways that are part of a means of egress, are presented in the following pages.

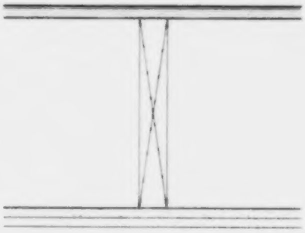
BW-1: Balcony / Walkway–Exposed Membrane Assembly



Balcony

TRAFFIC MEMBRANE SYSTEM
SHEATHING
JOISTS
VENTED SOFFIT PANELS

TRAFFIC MEMBRANE SYSTEM
SHEATHING
JOISTS
EXTERIOR GYPSUM BOARD
METAL OR VINYL SOFFIT PANELS



Walkway

MOISTURE BARRIER

This assembly anticipates the control of all of the moisture at the waterproof membrane. It does not anticipate the presence of exterior moisture within the wood framing and is therefore a face seal assembly. The assembly is sensitive to exterior moisture that penetrates, at a leak location, to the wood sheathing and framing. The venting capability of the balcony assembly will help to dry the assembly in the event of a minor leak or condensation.

AIR BARRIER

Not applicable.

VAPOUR BARRIER

Not applicable.

LIMITATIONS ON USE

The continuity of the roof membrane system is critical in this assembly and essential for good performance. However, it is not a recommended assembly for high or medium traffic situations. Some membranes are particularly non-durable and therefore the selection of the membrane is critical to the performance of the assembly.

DOCUMENTED LIMITATIONS

Many of these assemblies are in service and have provided good performance. However, many have not, primarily due to the issues discussed above under Limitations on Use. Positive drainage, installation, and detailing are critical for the performance of the assembly.

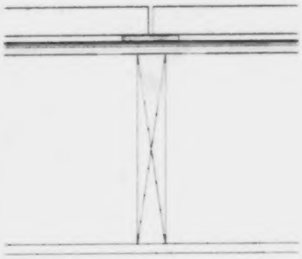
DURABILITY

The assembly is sensitive to moisture that reaches the sheathing and framing and therefore detailing the interfaces and selecting the membrane material type are both significant factors in the overall performance and durability of the assembly.

The horizontal and exposed nature of the waterproof membrane system may contribute to a shortened life expectancy of this assembly due to potentially increased loading, including mechanical damage, pedestrian traffic, water ponding and freezing, thermal cycling and resistance to ultra-violet light.

Draining the membrane is fundamental to its durable performance, and therefore the location and sizing of drains, and providing a positive slope to the drains are critical design features.

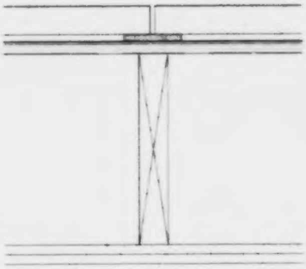
BW-2: Balcony / Walkway–Protected Membrane Assembly



Balcony

DECK SURFACE (concrete pavers)
PEDESTALS OR DRAINAGE COMPOSITE
WATERPROOF ROOF MEMBRANE SYSTEM
SHEATHING
JOISTS
VENTED SOFFIT PANELS

DECK SURFACE (concrete pavers)
PEDESTALS OR DRAINAGE COMPOSITE
WATERPROOF ROOF MEMBRANE SYSTEM
SHEATHING
JOISTS
EXTERIOR GYPSUM BOARD
SOFFIT PANELS



Walkway

MOISTURE BARRIER

This assembly anticipates the control of the majority of the exterior moisture at the waterproof deck membrane system with some water shed to the drainage system by the deck surface. The assembly is sensitive to exterior moisture that penetrates, at a leak location, to the sheathing and framing. The venting capability of this assembly will help dry the assembly in the event of a minor leak or condensation.

AIR BARRIER

Not applicable.

VAPOUR BARRIER

Not applicable.

LIMITATIONS ON USE

Good performance can be expected in most situations.

DOCUMENTED LIMITATIONS

Many of these assemblies are in service and have provided good service.

DURABILITY

The assembly is sensitive to moisture that reaches the sheathing and framing. Therefore, both detailing the interfaces and selecting the membrane material type are significant factors in the overall performance and durability of the assembly.

Draining the membrane is fundamental to its durable performance, and therefore the location and sizing of drains, and providing positive slope to the drains are critical design features.

The waterproof membrane system in this assembly is protected from loading, including thermal cycling, is resistant to ultra-violet light and pedestrian traffic, and therefore provides a relatively durable assembly, with less maintenance requirements than exposed membrane systems.

WINDOW ASSEMBLIES

Window assemblies must also be considered in the context of the principles presented in Chapter 3. Each of the assembly sheets that follow discuss how the window assembly addresses water management principles, as well as limitations on use and durability.

Water Management Strategy

The window frame assemblies have been classified as face seal, concealed barrier, or rainscreen. Similar to wall assemblies, window assemblies consist of both a water-shedding surface, which deflects most of the water, and a moisture barrier surface past which penetration of water is considered unacceptable. There are two sketches of the conceptual assembly at the top of each page. The bold line in the right-hand sketch shows the moisture barrier surface. A dashed line in the sketch on the left shows the water-shedding surface of the assembly.

Water leakage through windows manifests itself in two ways. It can show up as pools on the interior window frame sections where it then either evaporates or drains onto adjacent interior finishes. Alternately, water can leak through the window assembly into the wall assembly below. It has become common in the detailing of wall assemblies to assume that the window will leak and therefore provisions are made to drain water out of the assembly through the use of a sub-sill membrane flashing. This strategy will address water leakage into the wall assembly but will not address water penetration directly through the window to the interior. The use of a sub-sill is a prudent precaution but if it does not have a thermal break, there is an increased potential for condensation on the interior of the window sill. Care must be taken in the detailing and selecting of materials to avoid this problem.

Many of the window water leakage problems identified in the *Survey* were in fact problems associated with window assembly connections to the adjacent wall assemblies or in coupled window assemblies. Detailing of these interfaces is as important as the selection of an appropriate window assembly.

Air Barrier

The continuity of the air barrier is discussed on each sheet. Some window manufacturers incorporate holes that penetrate the air barrier and the moisture barrier. These holes have evolved as a low-cost response to either water leakage or condensation which collects in gutters on the interior surface of the frame. (This was a more relevant issue when frames without a thermal break were in use.) The intent is to permit drainage of this water back to the exterior through the holes. This compromise of one building science principle to accommodate another is not recommended.

The moisture barrier and the air barrier of window assemblies are almost always coincident, unlike wall or roof assemblies.

Vapour Barrier

The vapour barrier is not discussed since essentially all of the materials in the window assemblies presented have low vapour permeability.

Condensation Control

In the coastal climate zone, the provision of a thermal break in aluminum frame windows is sufficient to control condensation for normal residential occupancy. Vinyl windows are inherently resistant to the flow of heat and do not normally experience condensation problems.

Assembly sheets are presented for the six most common window categories, presented in the following Table 5.4.

The sills of fixed windows have been used to illustrate the fundamental differences between the most common window assemblies. The analysis applied to the classification of these window assemblies can be used to examine the performance of operable windows and others that do not fit into the six categories presented. It is recommended that all proposed window assemblies be assessed as to the effectiveness and durability of the water-shedding surface and moisture barriers. The illustrated assemblies can be used as a guide. This comparison analysis will assist in the selection of an appropriate window assembly.

Summarized in Table 5.4 are the window assemblies recommended for differing exposure categories. Refer to the individual assembly sheets for more details on the performance expectations.

Renewals

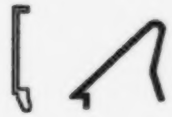
The use of flange style windows rather than rebate style windows may necessitate greater wall repair work at the window perimeter when window replacement is required as part of a renewals program. Careful detailing of the window perimeter conditions for flange style windows may minimize this additional work.

Table 5.4: Acceptable Window Assemblies for Exposure Categories

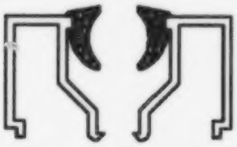
	RECOMMENDED MAXIMUM EXPOSURE LEVEL			
WINDOW ASSEMBLIES	None	Low	Medium	High
AL-1: Aluminum–Face Seal	✔	✔		
AL-2: Aluminum–Concealed Barrier	✔	✔		
AL-3: Aluminum–Concealed Barrier (Improved)	✔	✔	✔	
AL-4: Aluminum–Rainscreen	✔	✔	✔	✔
VY-1: Vinyl–Concealed Barrier	✔	✔	✔	
VY-2: Vinyl–Rainscreen	✔	✔	✔	✔

Window Component Definitions

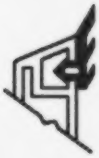
The following terms have been used in the description of the assemblies:



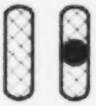
Removable glazing stop without gasket: metal or plastic stop to hold glazing unit against interior glazing tape or stop. This type of stop is not air or watertight.



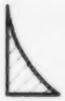
Dry gasket on removable glazing stop: same as above except that a gasket is used to apply pressure on the glazing unit. The use of a gasket improves the seal between the stop and the glazing unit, however water and air leakage usually occurs at the ends of the gasket or between horizontal and vertical removable glazing stops unless care is taken to seal these joints.



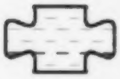
Dry gasket on fixed glazing stop: improved gasket installed into the fixed portion of the window frame before the glazing unit is installed. Joints in the gasket can be welded and joints in the frame can be sealed or welded to create a watertight joint between the frame and the glazing unit. In PVC windows it is also possible to co-extrude the gasket directly into the window frame.



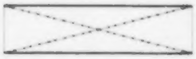
Glazing tape (unshimmed and shimmed): also known as a wet seal. Creates a watertight joint between the glazing unit and the fixed glazing stop on the window frame. Although both unshimmed and shimmed tapes are available, only shimmed tape is recommended.



Heel bead: high performance caulking or gasket between the window frame and the glazing unit to create an air and watertight seal. In the sheets which follow, a sealant fillet bead has been shown. It must be accompanied by a backer rod or bond breaker tape to provide support and proper shape to the sealant (see Chapter 7). Backer rods and bond breaker tape are not shown in the drawings for clarity.

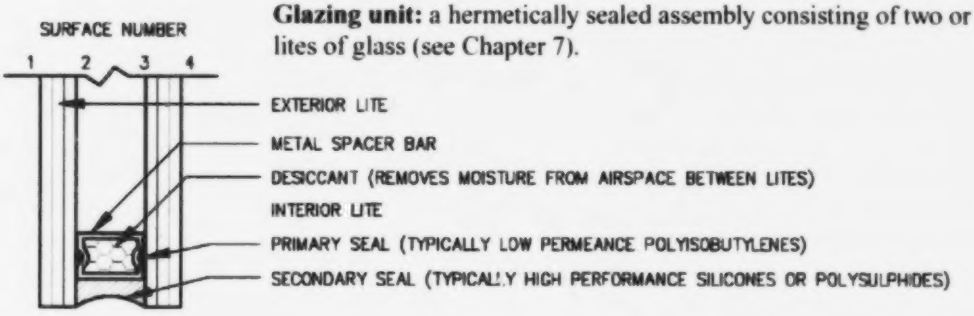


Thermal break: a low heat conducting layer between the interior and exterior portions of a metal frame to reduce heat flow and increase condensation resistance.



Setting block: set at 1/4 points, it provides support and protection for both lites of the glazing unit and keeps glazing unit perimeter seal above ponding water.

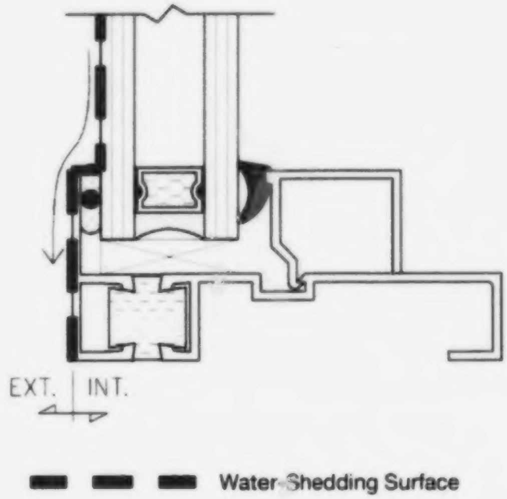
Glazing unit: a hermetically sealed assembly consisting of two or more lites of glass (see Chapter 7).

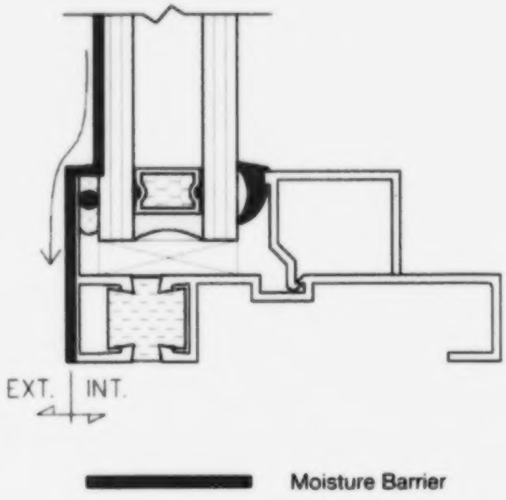

SURFACE NUMBER
1
2
3
4
EXTERIOR LITE
METAL SPACER BAR
DESICCANT (REMOVES MOISTURE FROM AIRSPACE BETWEEN LITES)
INTERIOR LITE
PRIMARY SEAL (TYPICALLY LOW PERMEANCE POLYISOBUTYLENES)
SECONDARY SEAL (TYPICALLY HIGH PERFORMANCE SILICONES OR POLYSULPHIDES)

Window AL1: Aluminum–Face Seal Window Assembly

Glazing Method: Interior

Window Type: Rebate or Equal Leg





WATER MANAGEMENT STRATEGY

Water-Shedding Surface: Water on the outer surface of the window assembly is deflected to the exterior by an air and watertight barrier consisting of the glazing unit, glazing tape (wet seal) and the frame.

Moisture Barrier: Same as water-shedding surface; water that infiltrates past the glazing tape will enter the building interior. If the frame butt and mitred joints have been adequately sealed, water leakage will show up on the interior of the frame instead of infiltrating into the wall assembly unnoticed.

AIR BARRIER

The air barrier in this system consists of the glass, glazing tape, and frame and is coincident with the moisture barrier.

LIMITATIONS ON USE

This system has no redundancy because both the water-shedding surface and the moisture barrier are at the same plane. Acceptable long-term performance can be expected under low exposure conditions where the assembly is rarely wetted from the exterior and the face seal is well maintained. When frequently exposed to wind-driven rain, this assembly will require frequent maintenance to maintain the exterior face seal and minimize water infiltration.

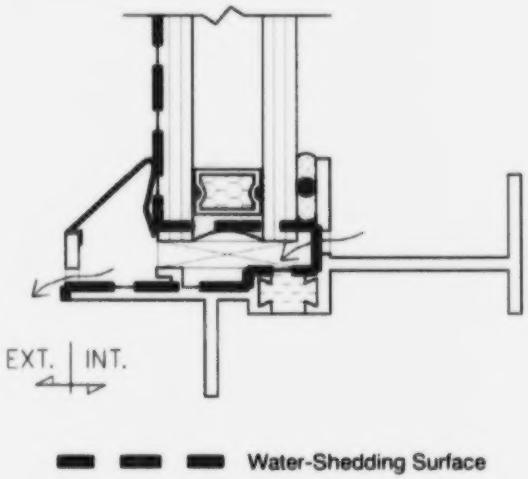
DURABILITY

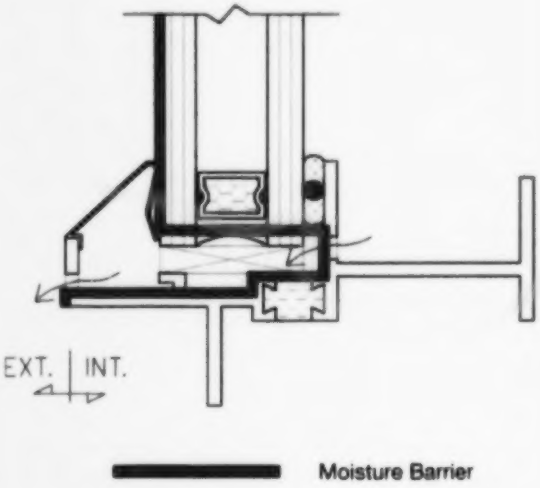
The assembly is very sensitive to the continuity of the face seal. Therefore maintaining interfaces (glazing tape seal and frame butt and mitre joints) and minimizing the amount of water impacting on the assembly are both significant factors in the overall performance and durability of the assembly.

Window AL2: Aluminum–Concealed Barrier Window Assembly

Glazing Method: Exterior

Window Type: Rebate or nail-on flange (nail-on shown))





WATER MANAGEMENT STRATEGY

Water-Shedding Surface: This type of window has a very poor water-shedding surface. The lack of any seals or gaskets on the exterior allows a significant quantity of the water on the outer surface of the window to flow through the unsealed joint between the exterior removable glazing stop and the glazing unit and enter the window assembly. This results in the effective water-shedding surface being in the same plane as the moisture barrier.

Moisture Barrier: Water is prevented from entering into the building by the glazing unit, by the glazing tape on the interior of the glazing unit, by the window frame, and by the sealants at fasteners and joints in the framing at corners. Typically, water that by-passes the glazing stop and enters the cavity at the perimeter of the glazing unit, drains back to the exterior through weep holes in the face of the frame. Physical restrictions such as screw splines or raised profiles in the frame (note the possible restriction under the left side of the setting block), cause water to be retained in the glazing cavity.

AIR BARRIER

The air barrier in this system consists of the glazing units, glazing tape and the window frame. Holes left in the interior fixed glazing leg for the drainage of moisture will allow uncontrolled air leakage through the assembly. This will increase the water flow into the glazing cavity due to the increased air flow past the glazing stops.

LIMITATIONS ON USE

This system has no redundancy because both the water-shedding surface and the moisture barrier are at the same plane. Acceptable long-term performance can only be expected under low exposure conditions, where the assembly is rarely wetted from the exterior. Maintenance of the frame sealant is difficult, costly, and is not always effective in reducing leakage once frame joints have failed.

DURABILITY

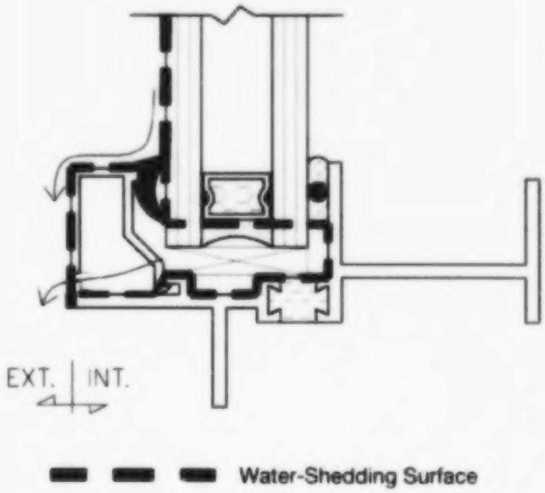
The assembly is very sensitive to the continuity of the frame sealant.

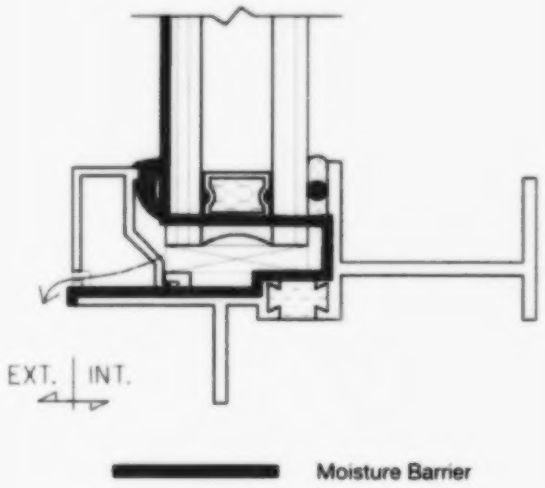
Minimizing the amount of water impacting on the assembly is a significant factor in the overall performance and durability of this assembly.

Window AL3: Aluminum–Concealed Barrier Window Assembly (improved glazing [illegible]

Glazing Method: Exterior

Window Type: Rebate or nail-on flange (nail-on shown)





WATER MANAGEMENT STRATEGY

Water-Shedding Surface: The exterior gasket reduces the quantity of water infiltration between the removable glazing stop and the glazing unit compared to the conventional concealed barrier assembly. The elimination of the holes through the frame glazing leg in the aluminum concealed barrier window assembly (AL-2) improves the performance of the water-shedding surface by pressure equalizing the glazing cavity.

Moisture Barrier: Water is prevented from entering the building by the glazing tape on the interior of the glazing unit, by the window frame, and by sealants at fasteners and joints in the framing at corners. Water that enters the window system is allowed to drain back to the exterior provided that drain holes are installed and there are no physical restrictions such as screw splines or raised profiles in the frame.

AIR BARRIER

The air barrier in this system consists of the glazing unit, glazing tape between the glass and window frame, and the window frame.

LIMITATIONS ON USE

The water-shedding surface is improved from that of the conventional concealed barrier assembly (AL-2) and this will reduce the quantity of water coming into contact with the moisture barrier. However, some water is still expected to enter the glazing cavity and contact the moisture barrier when the window is exposed to wind-driven rain. This lack of redundancy means that acceptable long-term performance can only be expected under medium exposure conditions. Maintenance of the internal sealants is difficult, costly, and not always effective in reducing leakage if the frame joints have failed.

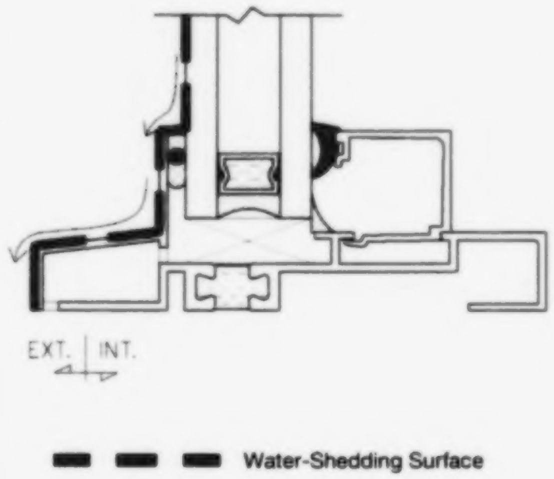
DURABILITY

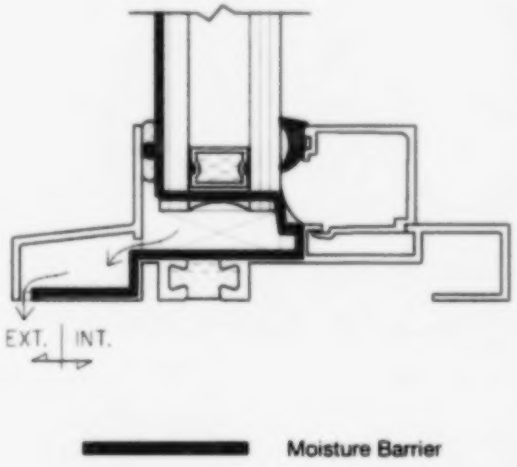
The assembly is very sensitive to the continuity of the internal sealants. The durability of the internal sealants is usually less than the metal frame materials when they are submerged in water. In addition, the maintenance of the internal sealants is difficult. Minimizing the quantity of water impacting on the assembly is a significant factor in the overall performance and durability of this assembly. Some manufacturers are incorporating more durable materials such as PVC gaskets, and are designing better drainage and water-shedding surfaces. Increasing the performance of these components will increase the performance and durability of the overall window assembly.

Window AL4: Aluminum–Rainscreen Window Assembly

Glazing Method: Interior

Window Type: Flush or Rebate





WATER MANAGEMENT STRATEGY

Water-Shedding Surface: Water contacting the outer surface of the window assembly is deflected to the exterior by a combination of the glazing, the exterior wet seal (glazing tape) or rubber gasket and the window frame. This type of water-shedding surface is effective in deflecting the majority of the water that comes into contact with the window on the exterior.

Moisture Barrier: If a minor amount of water infiltrates past the water-shedding surface, it will enter the window assembly, but it is prevented from entering the building by the moisture barrier. The moisture barrier consists of a heel bead or rubber gasket around the interior of the glazing unit, the window frame, and by sealants at fasteners and joints in the framing at corners. Water that enters the window system is allowed to drain back to the exterior provided that drain holes are installed and there are no physical restrictions such as screw splines or raised profiles in the frame.

AIR BARRIER

The air barrier in this system consists of the glazing unit, the heel bead between the glass and window frame, and the window frame itself.

LIMITATIONS ON USE

The water-shedding surface is independent of the moisture barrier in this system and both are intended to be effective at preventing water infiltration. This redundancy typically allows acceptable performance to be expected under low, medium and high exposure conditions.

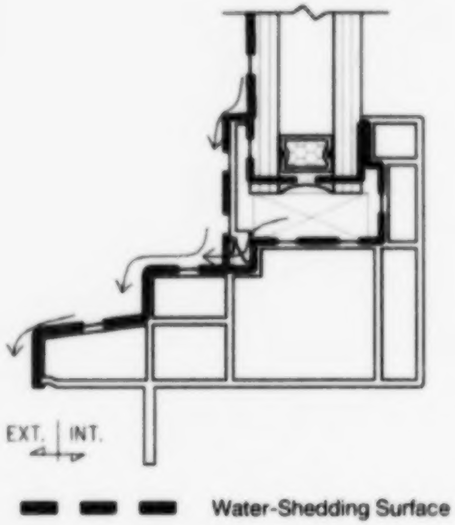
DURABILITY

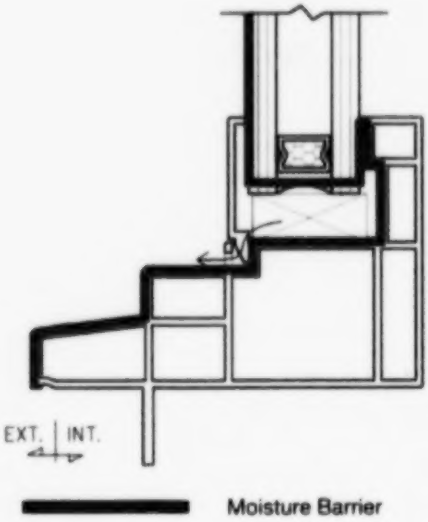
This design essentially incorporates both the exterior seal from the face sealed system and the interior seal from the concealed barrier system. This dual seal approach reduces the sensitivity of the system to a failure or deterioration of one component. Quality control during manufacturing and the quality of the seals used are both significant factors in the overall performance and durability of the assembly.

Window VY-1: Vinyl–Concealed Barrier Window Assembly

Glazing Method: Exterior

Window Type: Rebate or nail-on (nail-on shown)





WATER MANAGEMENT STRATEGY

Water-Shedding Surface: The lack of exterior gaskets or seals allows significant quantities of water to enter the assembly by flowing through the joint between the exterior removable glazing stop and the glazing unit.

Moisture Barrier: Water is prevented from entering into the building by a moisture barrier consisting of the window frame, the welded joints in the framing at corners, and the sealants at fasteners. Water that enters the window assembly is allowed to drain back to the exterior so long as drain holes are provided and there are no physical restrictions such as screw splines or raised profiles in the frame.

AIR BARRIER

The air barrier in this system consists of the glazing unit, the joint between the glass and fixed glazing leg on the window frame, and the window frame itself.

LIMITATIONS ON USE

The water-shedding surface will allow water to enter the glazing cavity and contact the moisture barrier when the window is exposed to wind-driven rain. This lack of redundancy means that acceptable long-term performance can only be expected under low to medium exposure conditions.

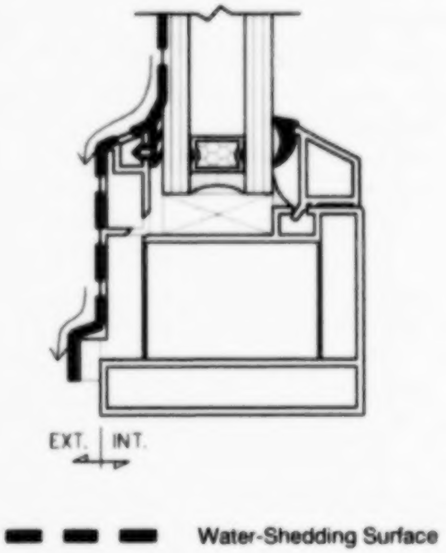
DURABILITY

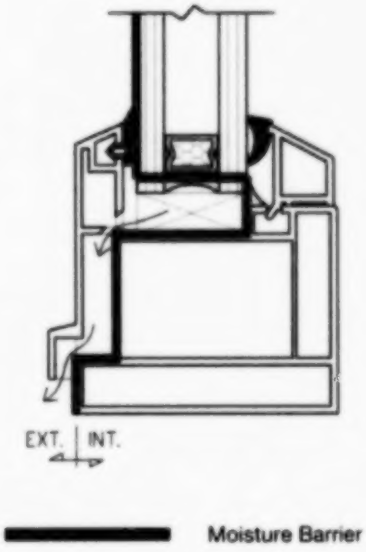
The assembly is very sensitive to the continuity of the welded joints in the frame and the internal sealants at the fasteners. One advantage over aluminum is that internal frame joints can be fusion-welded, making them watertight and of similar durability as the framing. Installing fasteners outside of the fusion-welded frame joints to minimize contact with water can increase the durability of the assembly. Minimizing exposure, quality control during manufacturing, and the design of the assembly are significant factors in the overall performance and durability of this assembly.

Window VY-2: Vinyl–Rainscreen Window Assembly

Glazing Method: Interior

Window Type: Flush or Rebate





WATER MANAGEMENT STRATEGY

Water-Shedding Surface: Water contacting the outer surface of the window assembly is deflected to the exterior by a combination of the glazing, exterior wet or dry seal (glazing tape or gasket) and the window frame. The window is interior glazed and this allows the exterior gaskets to be welded at joints before the glazing unit is installed, making the exterior seal extremely effective at deflecting water.

Moisture Barrier: The intent of the water-shedding surface is to prevent water from entering the glazing cavity. If a minor amount of water infiltrates past the water-shedding surface, it will enter the window assembly but is prevented from entering the building by the moisture barrier. The moisture barrier consists of a heel bead or gasket around the interior of the glazing unit, the welded joints in the window frame, and by sealants at fasteners. Water that enters the window system is allowed to drain back to the exterior provided that drain holes are provided and there is nothing to restrict drainage.

AIR BARRIER

The air barrier in this system consists of the glazing unit, the heel bead or rubber gasket between the glass and window frame, and the frame itself. Some manufacturers seal joints in the interior glazing stops and the interior dry seal to create an air and water barrier.

LIMITATIONS ON USE

The water-shedding surface is independent of the moisture barrier in this system and both are intended to be effective at preventing water infiltration. This redundancy typically allows acceptable performance to be expected under low, medium and high exposure conditions.

DURABILITY

This design essentially incorporates both the exterior seal from the face sealed system and the interior seal from the concealed barrier system. This dual seal approach reduces the sensitivity of the system to a failure or deterioration of one component. Quality control during manufacturing and the quality of the seals used are both significant factors in the overall performance and durability of the assembly.

CHAPTER 6

DETAILS

GENERAL

The details shown are intended to illustrate responses to the building science issues discussed previously. They should be used with the assemblies illustrated in the previous chapter. The particular design parameters are arbitrary. An actual building design would require an analysis of its unique set of conditions. Each building has a different combination of interior environment, exterior exposure and desired aesthetics, all of which have an impact on the design of its details.

In developing details for a specific project it is important to recognize the relative service lives and maintenance requirements of the various materials and components. The detailing must facilitate appropriate sequencing of renewal activities. For example, if a balcony membrane requires replacement every 10 years can this replacement be accomplished without dismantling the wall assembly?

There is considerable misunderstanding of various airtightness strategies. This has prompted the inclusion of sets of details which illustrate three of the possible approaches to achieving airtightness. Details marked SPA beside the detail number illustrate the sealed polyethylene approach, details marked ADA illustrate the airtight drywall approach. The details marked EABA illustrate an exterior air barrier approach.

In order to accommodate the various air barrier strategies two different wall assemblies have been illustrated. A stucco–rainscreen wall assembly (ST-3) is used in all SPA and ADA details. A stucco–exterior insulation rainscreen wall assembly (ST-4) is used in all EABA details. In some details alternate cladding materials are shown to illustrate differences between stucco and other cladding applications.

Various roof assemblies are shown to illustrate alternative interface details between the walls and the roof.

Table 6.1: List of Two-Dimensional Details

Detail	Air barrier strategy shown[1]			
	SPA	ADA	EABA	N.A.
1. Foundation wall at slab	✓			
2. Base of wall/foundation	✓	✓	✓	
3. Base of wall/concrete parking deck	✓	✓	✓	
4. Rim joist	✓	✓	✓	
5. Water-shedding roof/wall	✓	✓	✓	
6. Waterproof membrane roof/wall	✓	✓	✓	
7. Cantilevered floor	✓	✓	✓	
8. Exterior corner	✓		✓	
9. Interior corner	✓	✓	✓	
10. Cladding transition	✓			
11. Window head	✓	✓	✓	
12. Window jamb	✓	✓	✓	
13. Window sill	✓	✓	✓	
14. Door sill–protected membrane pedestrian surface	✓			
15. Door sill–exposed membrane pedestrian surface	✓			
16. Accessible door sill–protected membrane pedestrian surface	✓			
17. Accessible door sill–exposed membrane pedestrian surface	✓			
18. Door sill–pedestrian surface roof	✓	✓	✓	
19. Wall–pedestrian surface	✓			
20. Exterior edges–pedestrian surface				✓
21. Railing attachment at wall	✓			
22. Exterior element–wall	✓			
23. Exterior element–column				✓
24. Glass block–head	✓			
25. Glass block–jamb	✓			
26. Glass block–sill	✓			
27. Wall exhaust vent	✓			
28. Electrical fixtures				✓
29. Pipes				✓

[1] SPA: sealed polyethylene approach
ADA: airtight drywall approach
EABA: exterior air barrier approach

N.A. = No air barrier shown

DETAIL DRAWINGS

The details presented here are also included as drawing files on the accompanying CD-ROM. Both two-dimensional and three-dimensional details are presented. They do not address all possible situations that may arise. Rather they focus on the most common details and many which can be problematic. The two-dimensional details are included on the accompanying CD-ROM in DXF format, which can be used on both Mac and PC platforms, and DWG, which is AutoCad 12 format. Each of the three-dimensional details is a simplified print based on the sequential 4-D slide presentation which is also included on the accompanying CD-ROM in an executable HTML format. The three-dimensional details illustrate possible sequencing scenarios for some of the more complicated details.

DETAIL 1–FOUNDATION WALL AT SLAB

Wood in Contact with Concrete

One of the principles presented in Chapter 2 is the use of pressure-treated wood whenever it is placed in contact with concrete. This is because of the water wicking capabilities of concrete that could wet the wood. These capabilities could wet the wood. In this detail, pressure-treated wood blocking is used to separate the basement framing from the floor slab, and sheathing paper has been used to separate the framing from the concrete foundation wall. The use of blocking also allows for some drainage and drying from under the wall sill plate in the event of accidental water being present in the basement.

Use of Waterproofing on Foundation Walls

Damp-proofing and drainage composite are shown on the exterior side of the foundation wall. Drainage composite will quickly drain away any water which is present at this interface, thus eliminating any hydrostatic head of water. Where a head of water is to be expected despite the drainage composite, a waterproof membrane should be used on the foundation wall.

Insulation

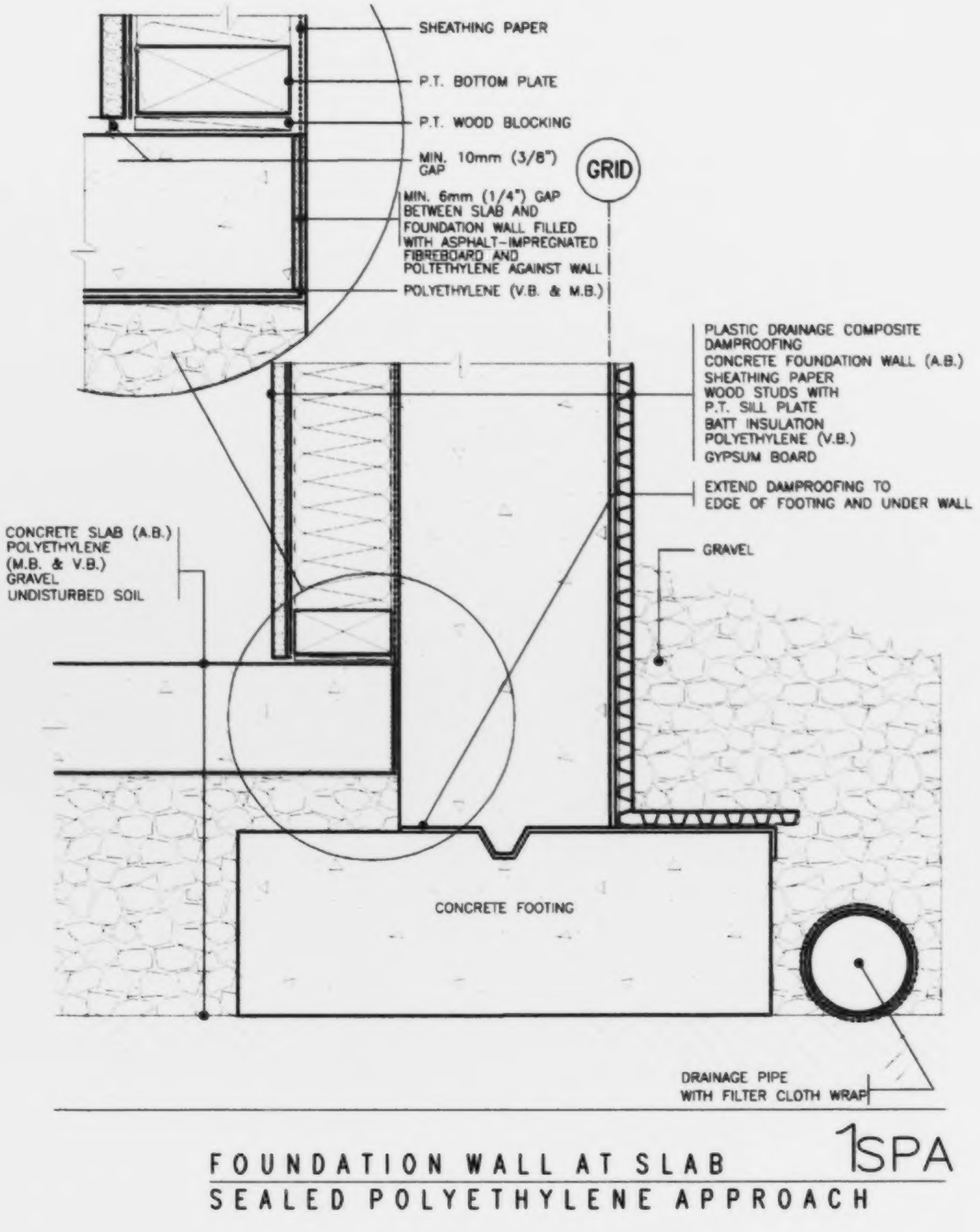
A 600 mm-wide strip of rigid perimeter insulation may be provided below the concrete slab at the junction with the foundation wall (not shown).

Air Barrier

The concrete foundation wall functions as the air barrier at this location.

Alternate Slab Configuration

Another possible configuration would position the slab directly on the footing. The risk of this alternate configuration is that the slab is more likely to crack at the support point at the edge of the footing.


SHEATHING PAPER
P.T. BOTTOM PLATE
P.T. WOOD BLOCKING
MIN. 10mm (3/8") GAP
GRID
MIN. 6mm (1/4") GAP BETWEEN SLAB AND FOUNDATION WALL FILLED WITH ASPHALT-IMPREGNATED FIBREBOARD AND POLTETHYLENE AGAINST WALL
POLYETHYLENE (V.B. & M.B.)
PLASTIC DRAINAGE COMPOSITE
DAMPROOFING
CONCRETE FOUNDATION WALL (A.B.)
SHEATHING PAPER
WOOD STUDS WITH P.T. SILL PLATE
BATT INSULATION
POLYETHYLENE (V.B.)
GYPSUM BOARD
EXTEND DAMPROOFING TO EDGE OF FOOTING AND UNDER WALL
GRAVEL
CONCRETE SLAB (A.B.)
POLYETHYLENE (M.B. & V.B.)
GRAVEL
UNDISTURBED SOIL
CONCRETE FOOTING
DRAINAGE PIPE WITH FILTER CLOTH WRAP
FOUNDATION WALL AT SLAB
SEALED POLYETHYLENE APPROACH
1SPA

Detail 1 SPA: Foundation Wall at Slab–Sealed Polyethylene Approach

DETAIL 2–BASE OF WALL/FOUNDATION

Parging

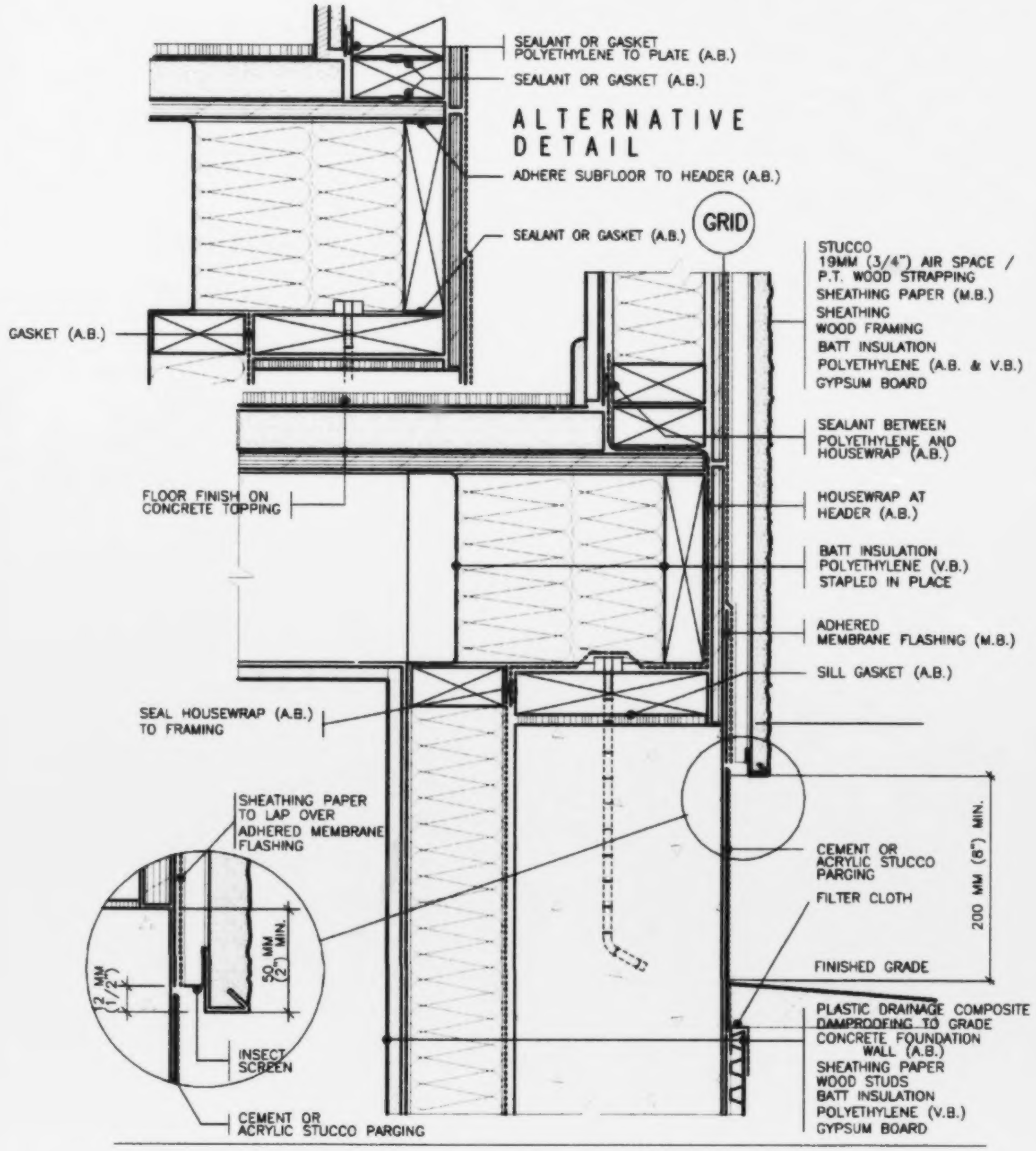
The parging on the exterior of the foundation may be sand and cement parging, or an acrylic coating, and is primarily used for aesthetics reasons.

Wood in Contact with Concrete

The sill gasket retards moisture rising through the concrete to the sill plate. However, the bottom plate should be pressure-treated due to its close proximity to the concrete surface. The sill gasket also forms the air seal between the top of the foundation wall and the sill plate.

Alternative Detail

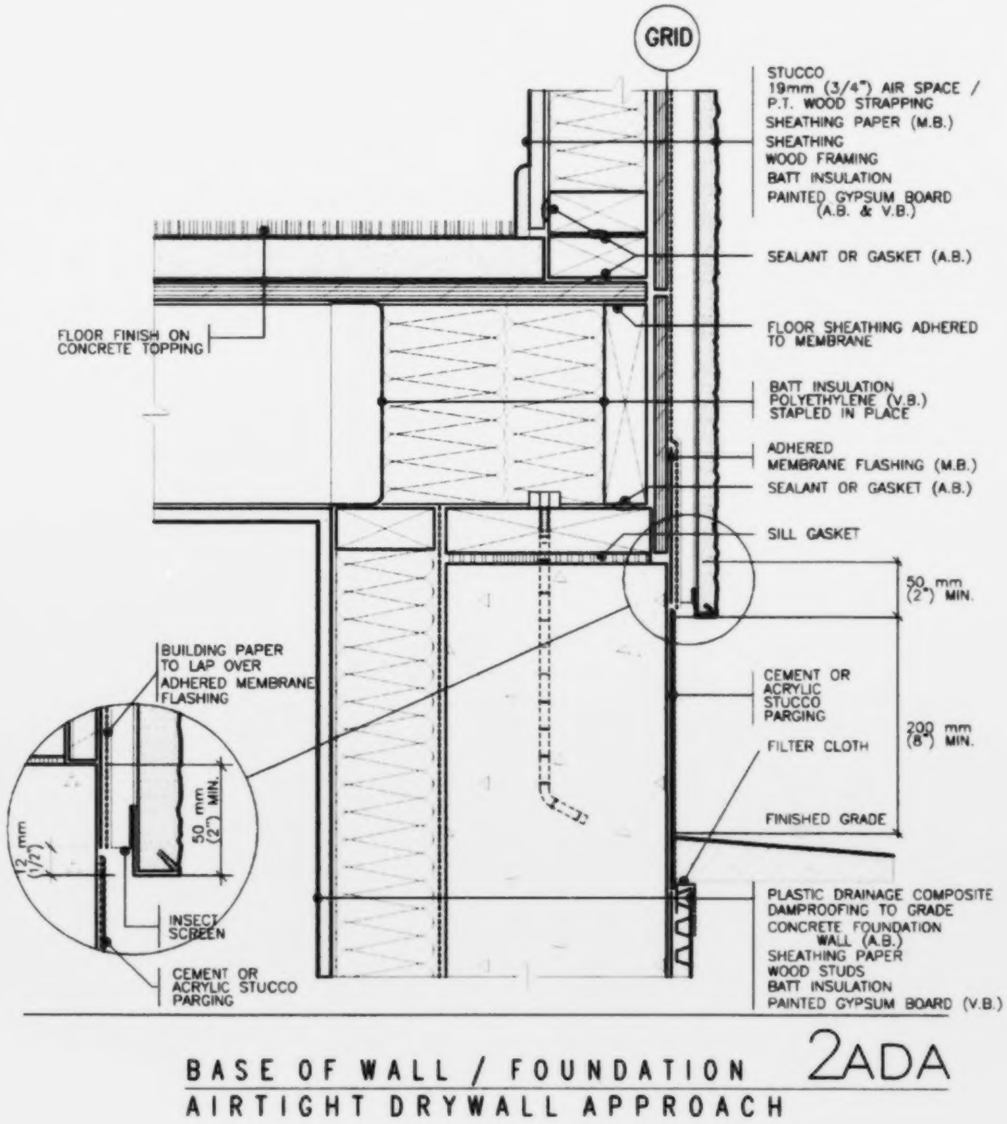
The alternative detail illustrates a second approach to achieving airtightness. The header housewrap is omitted and sealant or gaskets are used between framing members.


SEALANT OR GASKET
POLYETHYLENE TO PLATE (A.B.)
SEALANT OR GASKET (A.B.)
ALTERNATIVE
DETAIL
ADHERE SUBFLOOR TO HEADER (A.B.)
SEALANT OR GASKET (A.B.)
GRID
GASKET (A.B.)
STUCCO
19MM (3/4") AIR SPACE /
P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD
SEALANT BETWEEN
POLYETHYLENE AND
HOUSEWRAP (A.B.)
FLOOR FINISH ON
CONCRETE TOPPING
HOUSEWRAP AT
HEADER (A.B.)
BATT INSULATION
POLYETHYLENE (V.B.)
STAPLED IN PLACE
ADHERED
MEMBRANE FLASHING (M.B.)
SILL GASKET (A.B.)
SEAL HOUSEWRAP (A.B.)
TO FRAMING
SHEATHING PAPER
TO LAP OVER
ADHERED MEMBRANE
FLASHING
CEMENT OR
ACRYLIC STUCCO
PARGING
FILTER CLOTH
200 MM (8") MIN.
50 MM (2") MIN.
12 MM (1/2")
FINISHED GRADE
PLASTIC DRAINAGE COMPOSITE
DAMPROOFING TO GRADE
CONCRETE FOUNDATION
WALL (A.B.)
SHEATHING PAPER
WOOD STUDS
BATT INSULATION
POLYETHYLENE (V.B.)
GYPSUM BOARD
INSECT
SCREEN
CEMENT OR
ACRYLIC STUCCO PARGING

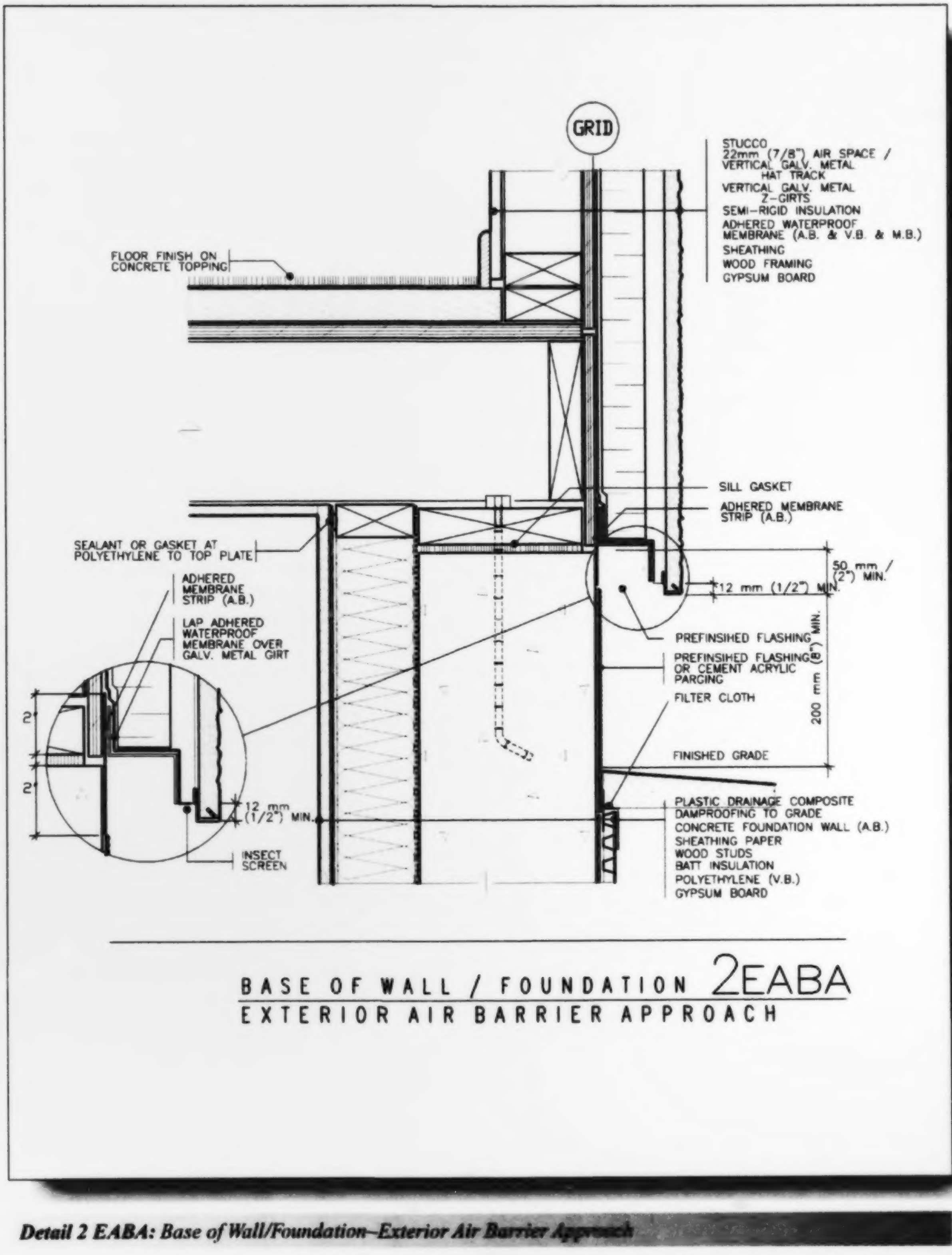
BASE OF WALL / FOUNDATION 2SPA

SEALED POLYETHYLENE APPROACH

Detail 2 SPA: Base of Wall/Foundation–Sealed Polyethylene Approach


GRID
STUCCO
19mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
PAINTED GYPSUM BOARD (A.B. & V.B.)
SEALANT OR GASKET (A.B.)
FLOOR FINISH ON CONCRETE TOPPING
FLOOR SHEATHING ADHERED TO MEMBRANE
BATT INSULATION
POLYETHYLENE (V.B.) STAPLED IN PLACE
ADHERED MEMBRANE FLASHING (M.B.)
SEALANT OR GASKET (A.B.)
SILL GASKET
50 mm (2") MIN.
BUILDING PAPER TO LAP OVER ADHERED MEMBRANE FLASHING
CEMENT OR ACRYLIC STUCCO PARGING
200 mm (8") MIN.
FILTER CLOTH
FINISHED GRADE
12 mm (1/2")
50 mm (2") MIN.
INSECT SCREEN
CEMENT OR ACRYLIC STUCCO PARGING
PLASTIC DRAINAGE COMPOSITE
DAMPROOFING TO GRADE
CONCRETE FOUNDATION WALL (A.B.)
SHEATHING PAPER
WOOD STUDS
BATT INSULATION
PAINTED GYPSUM BOARD (V.B.)
BASE OF WALL / FOUNDATION
2ADA
AIRTIGHT DRYWALL APPROACH

Detail 2 ADA: Base of Wall/Foundation–Airtight Drywall Approach


GRID
STUCCO
22mm (7/8") AIR SPACE / VERTICAL GALV. METAL HAT TRACK
VERTICAL GALV. METAL Z-GIRTS
SEMI-RIGID INSULATION
ADHERED WATERPROOF MEMBRANE (A.B. & V.B. & M.B.)
SHEATHING
WOOD FRAMING
GYPSUM BOARD
FLOOR FINISH ON CONCRETE TOPPING
SILL GASKET
ADHERED MEMBRANE STRIP (A.B.)
SEALANT OR GASKET AT POLYETHYLENE TO TOP PLATE
50 mm / (2") MIN.
12 mm (1/2") MIN.
ADHERED MEMBRANE STRIP (A.B.)
LAP ADHERED WATERPROOF MEMBRANE OVER GALV. METAL GIRT
PREFINSIHED FLASHING
PREFINSIHED FLASHING OR CEMENT ACRYLIC PARGING
200 mm (8") MIN.
FILTER CLOTH
FINISHED GRADE
2"
2"
12 mm (1/2") MIN.
INSECT SCREEN
PLASTIC DRAINAGE COMPOSITE
DAMPROOFING TO GRADE
CONCRETE FOUNDATION WALL (A.B.)
SHEATHING PAPER
WOOD STUDS
BATT INSULATION
POLYETHYLENE (V.B.)
GYPSUM BOARD
BASE OF WALL / FOUNDATION 2EABA
EXTERIOR AIR BARRIER APPROACH

Detail 2 EABA: Base of Wall/Foundation–Exterior Air Barrier Approach

DETAIL 3–BASE OF WALL/CONCRETE PARKING DECK

Sill Height

Whenever possible, door sills should be elevated 200 mm above the drainage surface of the parking deck. Increasing the height of the door sill above the drainage surface of the deck reduces the potential for water ingress as a result of snow melt or the back up of water on the drainage surface. (See also notes concerning accessible door sill, Details 16 and 17).

Curb

The wood curb shown represents common construction practice when framed construction is used above a concrete parking structure. An alternative, and better detail, would employ a poured-in-place concrete curb at this location.

Concrete Paver Placement

The concrete paver should be held back approximately 12 mm from the vertical membrane at the base of the curb to ensure that water can flow through the pavers and onto the membrane.

Membrane Flashing

The adhered membrane flashing under the door threshold should connect with a similar membrane wrapping the rough opening at the jambs. The method of providing air barrier continuity at the door jamb is similar to that shown on Detail 12.

Deck Membrane

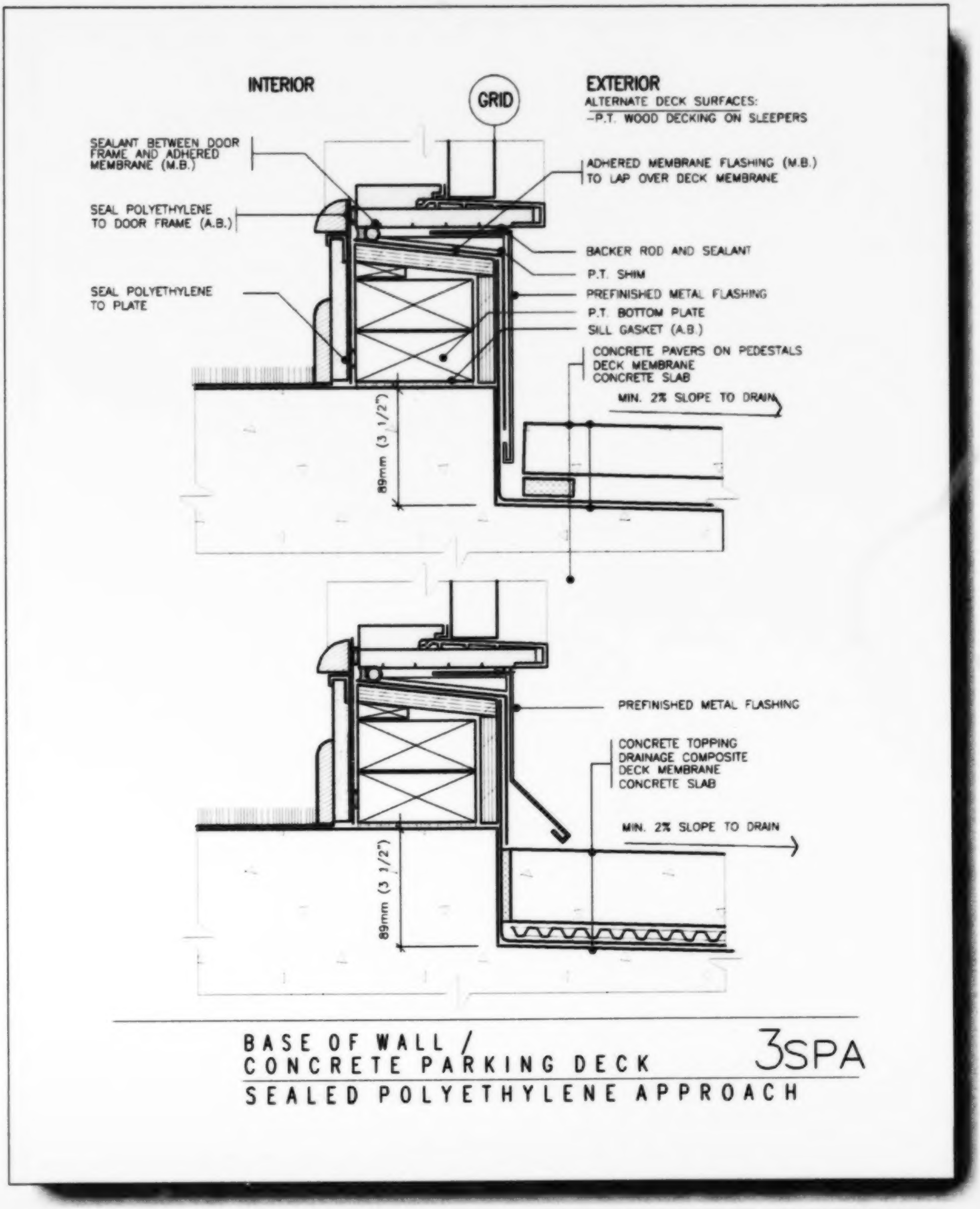
Application requirements and details for deck membranes vary. Manufacturers should be contacted to confirm specific product requirements for membrane reinforcing or cants at corners.

Metal Flashing

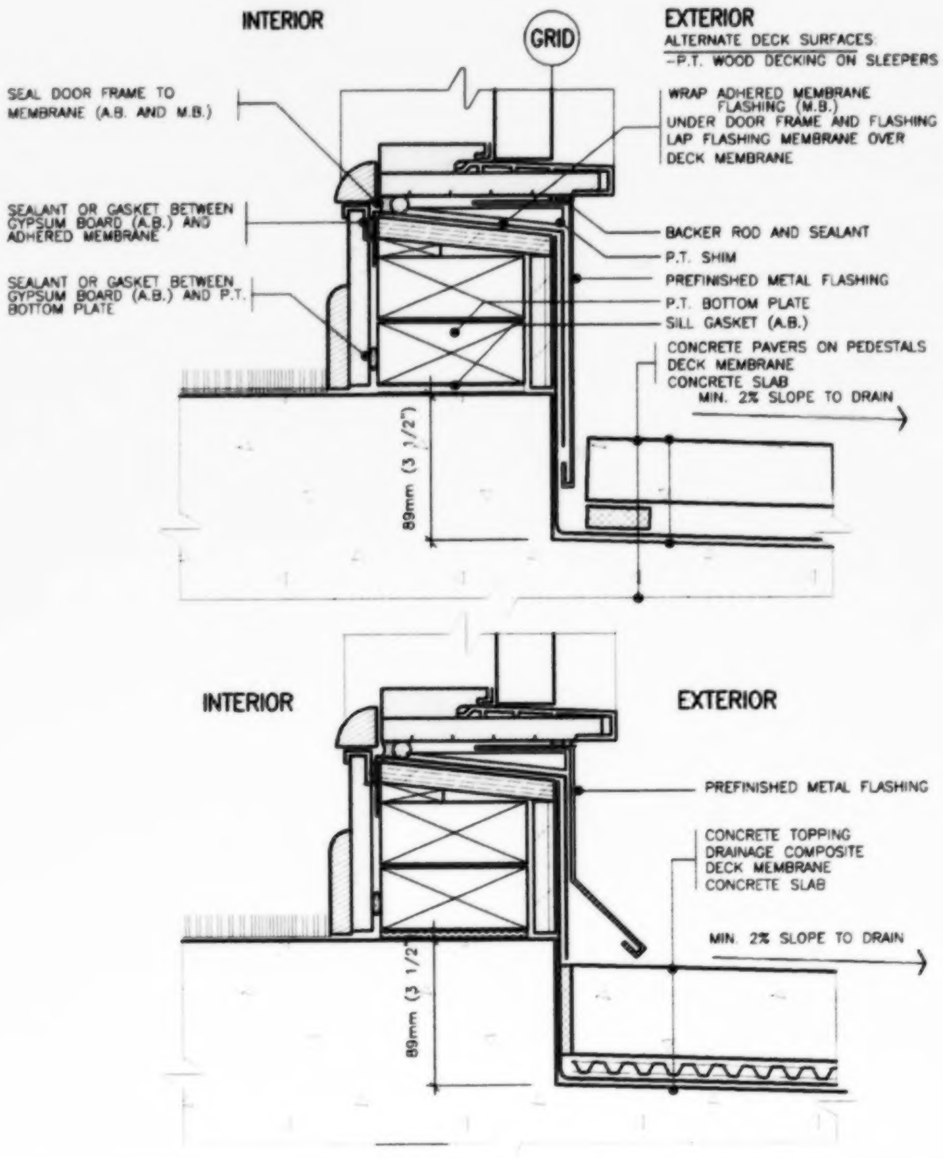
The pre-finished metal flashing should be kept a minimum of 12 mm off the surface of the concrete topping or deck membrane to reduce the time of wetting and potential for corrosion of the flashing.

Air Barrier

Air barrier continuity is achieved by sealing the polyethylene to the door frame and the bottom plate. The bottom plate is connected to the concrete slab through a sill gasket.


INTERIOR
GRID
EXTERIOR
ALTERNATE DECK SURFACES:
–P.T. WOOD DECKING ON SLEEPERS
SEALANT BETWEEN DOOR FRAME AND ADHERED MEMBRANE (M.B.)
ADHERED MEMBRANE FLASHING (M.B.) TO LAP OVER DECK MEMBRANE
SEAL POLYETHYLENE TO DOOR FRAME (A.B.)
BACKER ROD AND SEALANT
P.T. SHIM
SEAL POLYETHYLENE TO PLATE
PREFINISHED METAL FLASHING
P.T. BOTTOM PLATE
SILL GASKET (A.B.)
CONCRETE PAVERS ON PEDESTALS
DECK MEMBRANE
CONCRETE SLAB
MIN. 2% SLOPE TO DRAIN
89mm (3 1/2")
PREFINISHED METAL FLASHING
CONCRETE TOPPING
DRAINAGE COMPOSITE
DECK MEMBRANE
CONCRETE SLAB
MIN. 2% SLOPE TO DRAIN
89mm (3 1/2")
BASE OF WALL /
CONCRETE PARKING DECK
SEALED POLYETHYLENE APPROACH
3SPA

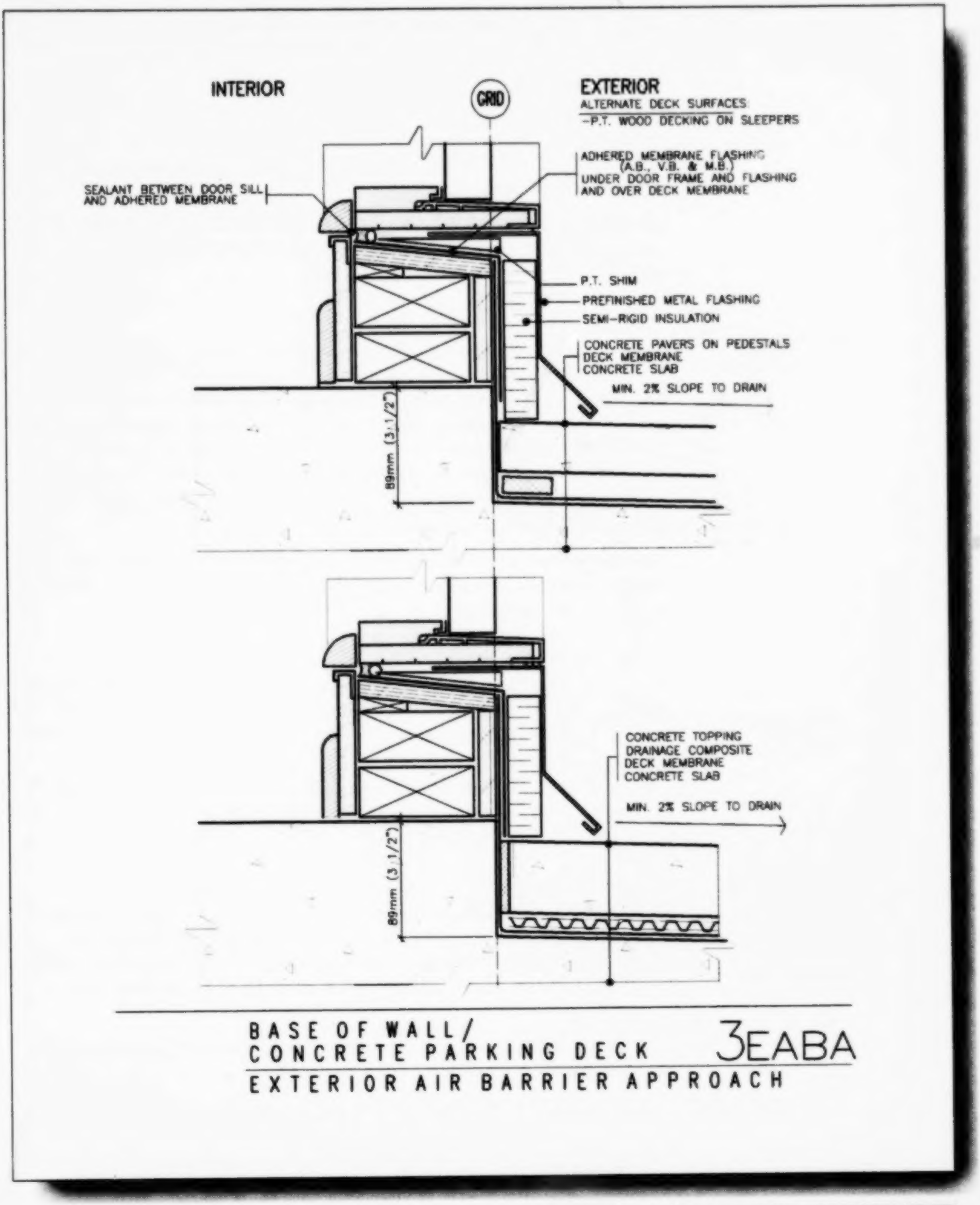
Detail 3 SPA: Base of Wall/Concrete Parking Deck–Sealed Polyethylene Approach


INTERIOR
GRID
EXTERIOR
ALTERNATE DECK SURFACES:
-P.T. WOOD DECKING ON SLEEPERS
SEAL DOOR FRAME TO MEMBRANE (A.B. AND M.B.)
WRAP ADHERED MEMBRANE FLASHING (M.B.) UNDER DOOR FRAME AND FLASHING LAP FLASHING MEMBRANE OVER DECK MEMBRANE
SEALANT OR GASKET BETWEEN GYPSUM BOARD (A.B.) AND ADHERED MEMBRANE
BACKER ROD AND SEALANT
P.T. SHIM
SEALANT OR GASKET BETWEEN GYPSUM BOARD (A.B.) AND P.T. BOTTOM PLATE
PREFINISHED METAL FLASHING
P.T. BOTTOM PLATE
SILL GASKET (A.B.)
CONCRETE PAVERS ON PEDESTALS
DECK MEMBRANE
CONCRETE SLAB
MIN. 2% SLOPE TO DRAIN
89mm (3 1/2")
INTERIOR
EXTERIOR
PREFINISHED METAL FLASHING
CONCRETE TOPPING
DRAINAGE COMPOSITE
DECK MEMBRANE
CONCRETE SLAB
MIN. 2% SLOPE TO DRAIN
89mm (3 1/2")

BASE OF WALL/
CONCRETE PARKING DECK
AIRTIGHT DRYWALL APPROACH

3ADA

Detail 3 ADA: Base of Wall/Concrete Parking Deck–Airtight Drywall Approach


INTERIOR
GRID
EXTERIOR
ALTERNATE DECK SURFACES:
-P.T. WOOD DECKING ON SLEEPERS
ADHERED MEMBRANE FLASHING (A.B., V.B. & M.B.) UNDER DOOR FRAME AND FLASHING AND OVER DECK MEMBRANE
SEALANT BETWEEN DOOR SILL AND ADHERED MEMBRANE
P.T. SHIM
PREFINISHED METAL FLASHING
SEMI-RIGID INSULATION
CONCRETE PAVERS ON PEDESTALS
DECK MEMBRANE
CONCRETE SLAB
MIN. 2% SLOPE TO DRAIN
89mm (3 1/2")
CONCRETE TOPPING
DRAINAGE COMPOSITE
DECK MEMBRANE
CONCRETE SLAB
MIN. 2% SLOPE TO DRAIN
89mm (3 1/2")
BASE OF WALL/
CONCRETE PARKING DECK
3EABA
EXTERIOR AIR BARRIER APPROACH

***Detail 3 EABA:* Base of Wall/Concrete Parking Deck–Exterior Air Barrier Approach**

DETAIL 4–RIM JOIST

Frame Shrinkage

A 6 mm gap is recommended between sheathing panels at the level of the top plates. The size of this gap has been based on the assumption that the structure has been constructed with wood members with a moisture content of 19 per cent or less.

Placement of the cross-cavity flashing at the level of the rim joist effectively creates a control joint to accommodate the shrinkage of the rim joist and plates.

Venting

At this time there are two schools of thought as to whether the top of the cavity should be vented at the level of the cross-cavity flashings. Venting the cavity at the cross-cavity flashing will increase the volume of air that passes through the cavity and hence will increase the potential to dry moisture from the cavity. However, venting at the top of the cavity may, under some circumstances, result in a negative pressure in the cavity which may draw water into the cavity, or alternately wind-driven rain may enter under its own momentum.

If the top of the cavity is to be vented, the blocking used to support the flashing should be discontinuous and the flashing should project 12 mm from the face of the cladding.

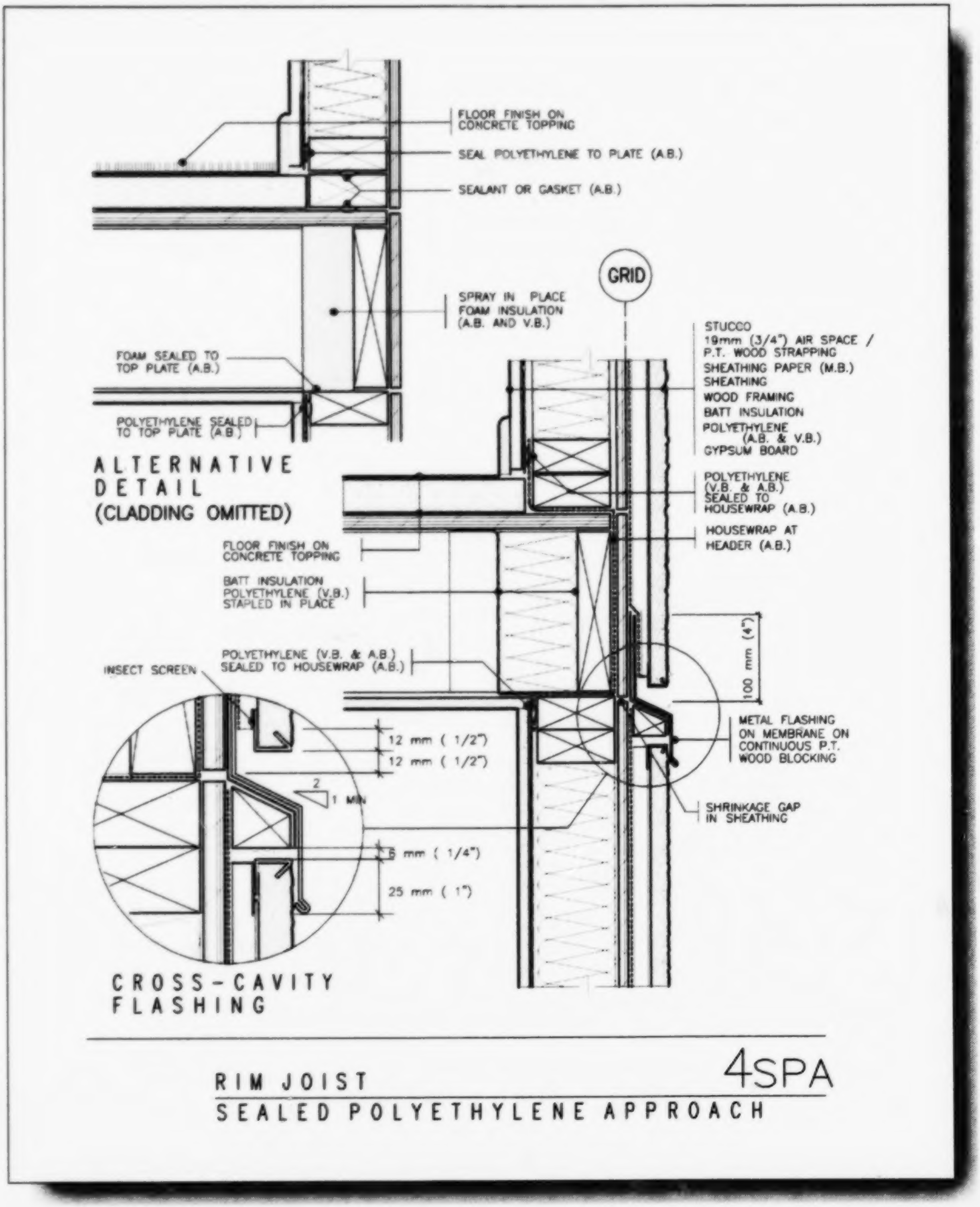
Cross-Cavity Flashing

The joints in the cross-cavity flashing should be designed and constructed to minimize the potential for water penetration. Joints at inside and outside corners should be standing seam. Joints in the straight run sections should be S-lock. Alternatively, as shown in this detail, a self-adhered membrane flashing may be used below the metal flashing and simpler lap joints may be used. Utilizing a 2:1 slope on the cross-cavity flashing reduces the potential for water to leak through at the joints.

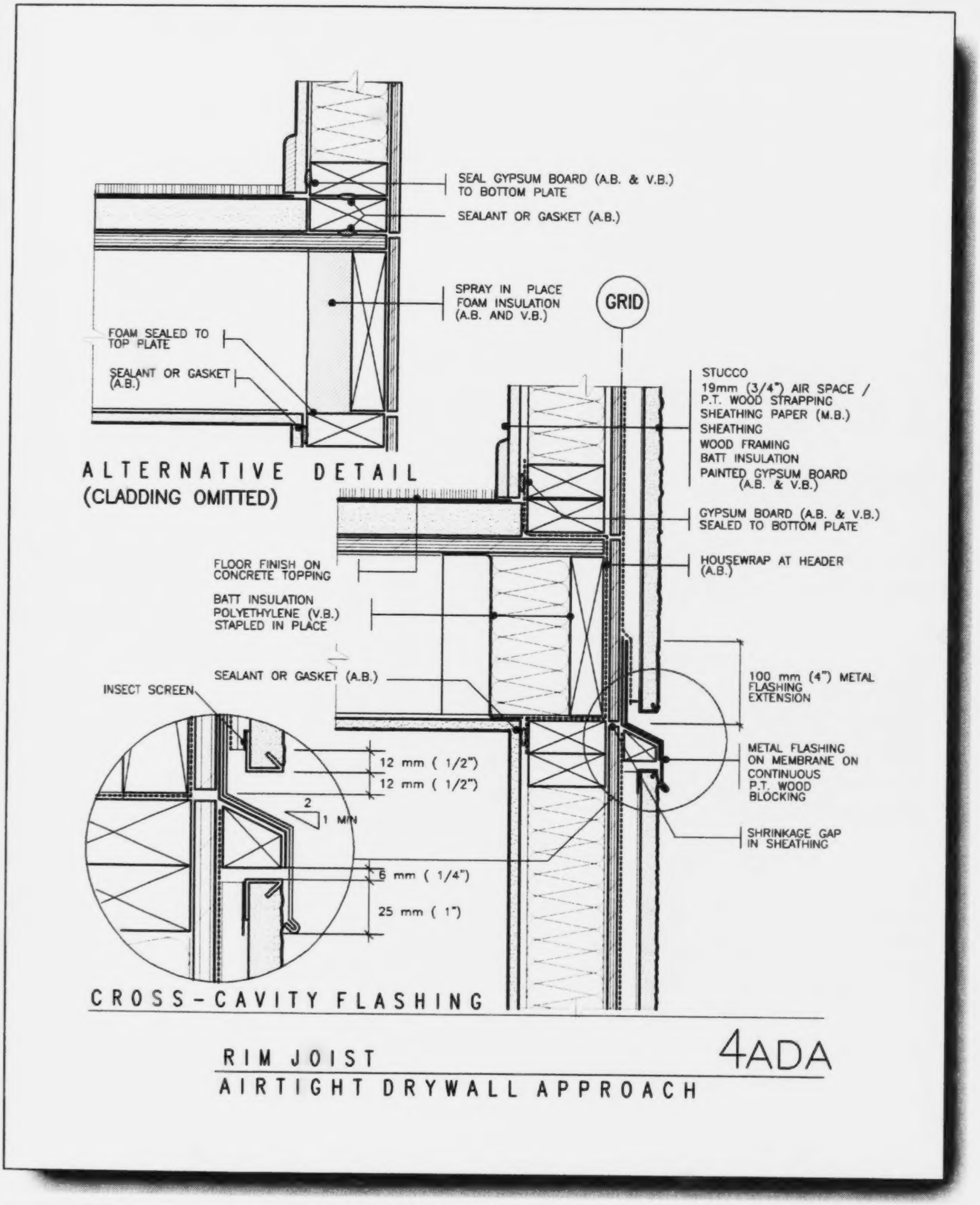
Alternative Detail

The alternative detail illustrates a second method of achieving airtightness at the rim joist. Implementation of this detail alleviates the problem of the header wrap being damaged during construction. This detail could be utilized if the header wrap is not installed before the upper level wall framing is constructed.

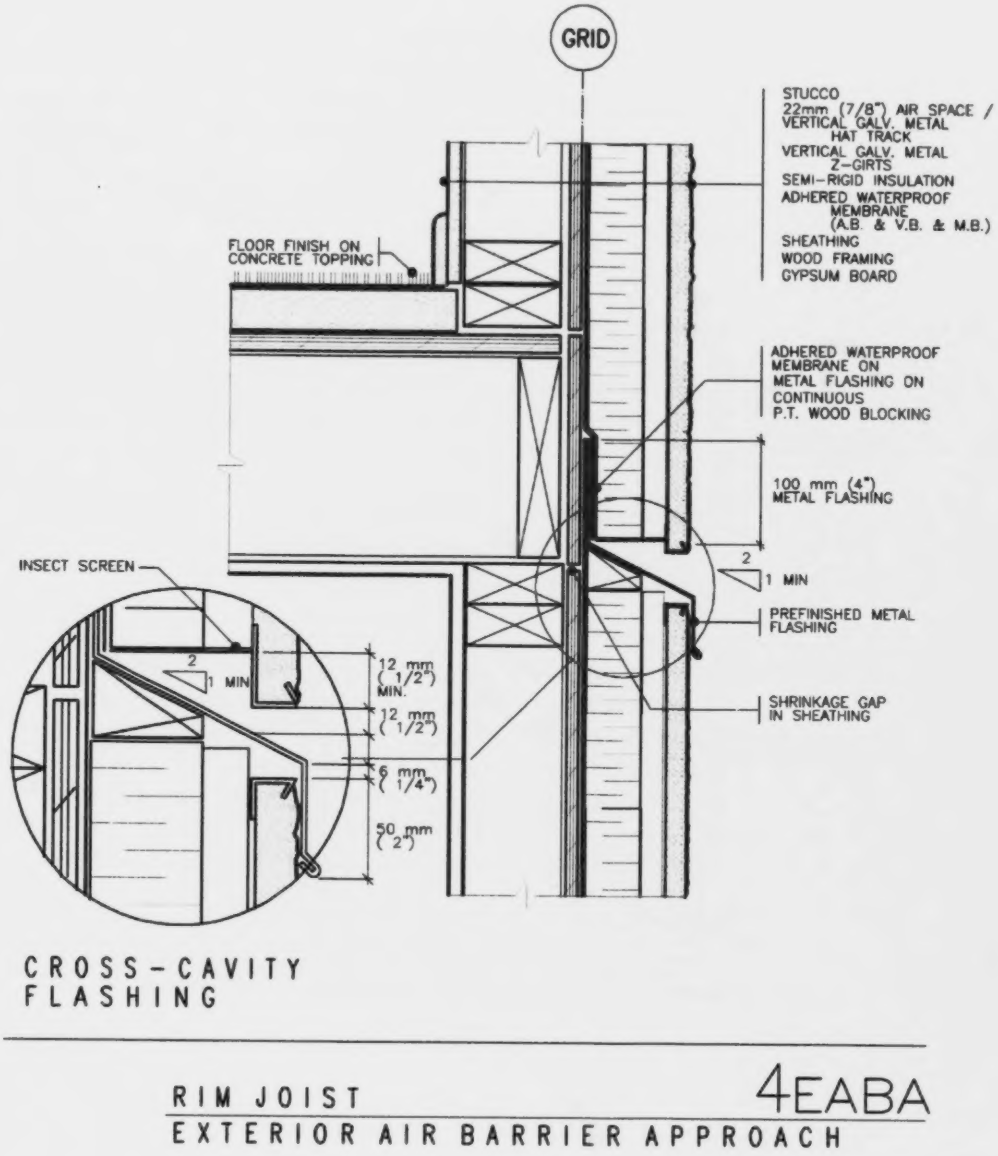
No vapour barrier is required when spray-in-place urethane foam insulation is used.


FLOOR FINISH ON CONCRETE TOPPING
SEAL POLYETHYLENE TO PLATE (A.B.)
SEALANT OR GASKET (A.B.)
SPRAY IN PLACE FOAM INSULATION (A.B. AND V.B.)
FOAM SEALED TO TOP PLATE (A.B.)
POLYETHYLENE SEALED TO TOP PLATE (A.B.)
ALTERNATIVE DETAIL (CLADDING OMITTED)
GRID
STUCCO
19mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD
POLYETHYLENE (V.B. & A.B.) SEALED TO HOUSEWRAP (A.B.)
HOUSEWRAP AT HEADER (A.B.)
FLOOR FINISH ON CONCRETE TOPPING
BATT INSULATION POLYETHYLENE (V.B.) STAPLED IN PLACE
POLYETHYLENE (V.B. & A.B.) SEALED TO HOUSEWRAP (A.B.)
INSECT SCREEN
100 mm (4")
METAL FLASHING ON MEMBRANE ON CONTINUOUS P.T. WOOD BLOCKING
SHRINKAGE GAP IN SHEATHING
12 mm (1/2")
12 mm (1/2")
2
1 MIN
6 mm (1/4")
25 mm (1")
CROSS-CAVITY FLASHING
RIM JOIST
SEALED POLYETHYLENE APPROACH
4SPA

Detail 4 SPA: Rim Joist–Sealed Polyethylene Approach


SEAL GYPSUM BOARD (A.B. & V.B.) TO BOTTOM PLATE
SEALANT OR GASKET (A.B.)
SPRAY IN PLACE FOAM INSULATION (A.B. AND V.B.)
FOAM SEALED TO TOP PLATE
SEALANT OR GASKET (A.B.)
ALTERNATIVE DETAIL (CLADDING OMITTED)
GRID
STUCCO
19mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
PAINTED GYPSUM BOARD (A.B. & V.B.)
GYPSUM BOARD (A.B. & V.B.) SEALED TO BOTTOM PLATE
HOUSEWRAP AT HEADER (A.B.)
FLOOR FINISH ON CONCRETE TOPPING
BATT INSULATION POLYETHYLENE (V.B.) STAPLED IN PLACE
SEALANT OR GASKET (A.B.)
INSECT SCREEN
100 mm (4") METAL FLASHING EXTENSION
METAL FLASHING ON MEMBRANE ON CONTINUOUS P.T. WOOD BLOCKING
12 mm (1/2")
12 mm (1/2")
2
1 MIN
6 mm (1/4")
25 mm (1")
SHRINKAGE GAP IN SHEATHING
CROSS-CAVITY FLASHING
RIM JOIST
AIRTIGHT DRYWALL APPROACH
4ADA

Detail 4 ADA: Rim Joist–Airtight Drywall Approach


GRID
STUCCO
22mm (7/8") AIR SPACE / VERTICAL GALV. METAL HAT TRACK
VERTICAL GALV. METAL Z-GIRTS
SEMI-RIGID INSULATION
ADHERED WATERPROOF MEMBRANE (A.B. & V.B. & M.B.)
SHEATHING
WOOD FRAMING
GYPSUM BOARD
FLOOR FINISH ON CONCRETE TOPPING
ADHERED WATERPROOF MEMBRANE ON METAL FLASHING ON CONTINUOUS P.T. WOOD BLOCKING
100 mm (4") METAL FLASHING
2
1 MIN
PREFINISHED METAL FLASHING
SHRINKAGE GAP IN SHEATHING
INSECT SCREEN
2
1 MIN
12 mm (1/2") MIN.
12 mm (1/2")
6 mm (1/4")
50 mm (2")
CROSS-CAVITY FLASHING
RIM JOIST
4EABA
EXTERIOR AIR BARRIER APPROACH

Detail 4 EABA: Rim Joist–Exterior Air Barrier Approach

DETAIL 5-WATER SHEDDING ROOF/WALL

Vented Soffits

In unsprinklered buildings, Clause 3.2.3.15 of the *British Columbia Building Code 1998* does not permit vented soffits at a roof overhang when a common attic space extends over more than two residential suites. Alternative means for venting the attic or roof space must be provided such as low profile roof jacks.

Insulation Guards

Placement of the insulation guards should be based on the venting requirements for the attic space. Section 9.19.1 of the *British Columbia Building Code 1998* requires that venting not be less than 1/300 (ratio of vent area to area of insulated ceiling), unless the roof has a slope less than 6:1, in which case the venting requirement is 1/150. The venting must be uniformly distributed with a minimum of 25 per cent of the venting area at the eaves and 25 per cent at the ridge.

Insulation Levels

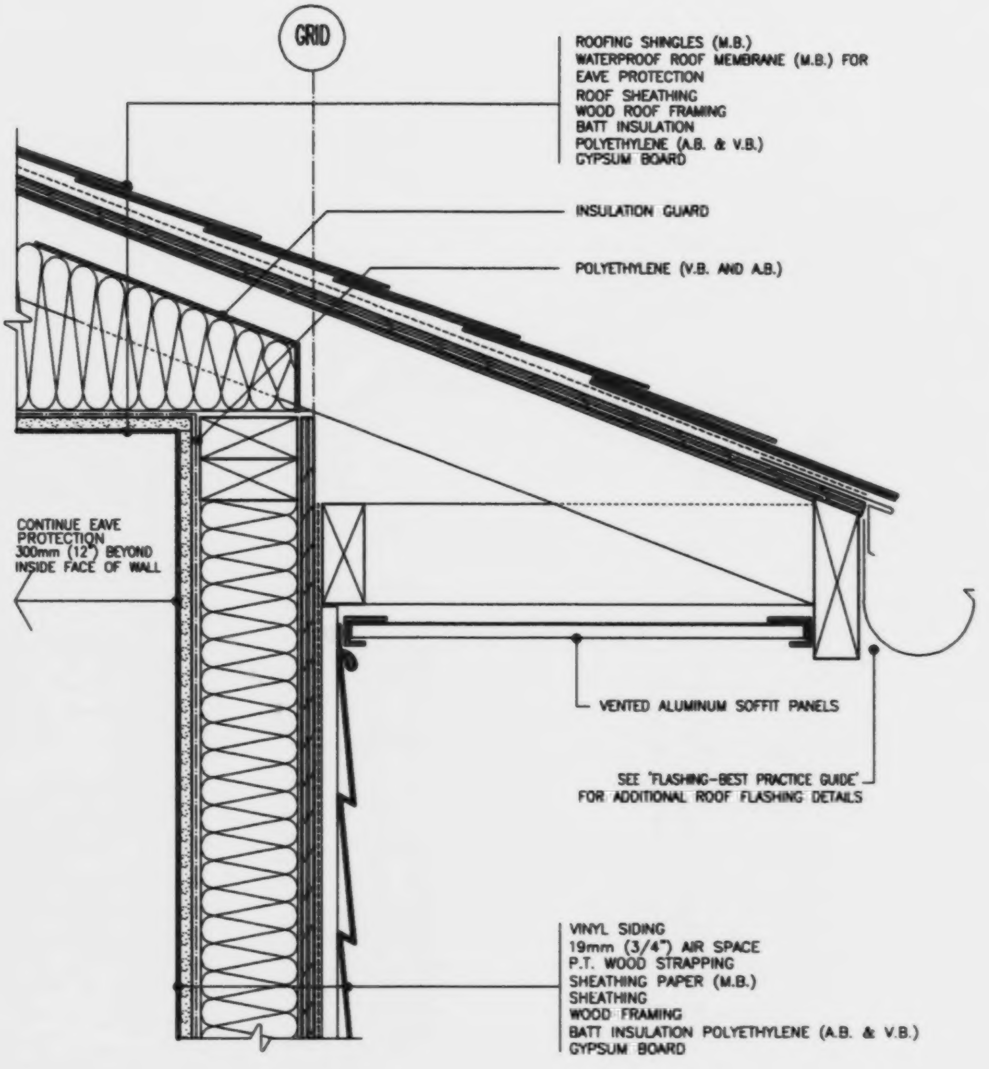
Providing minimum required insulation levels, and maintaining ventilation space above the guard, may require the use of high heel trusses.

Air Barrier

Care must be taken to ensure that the air barrier (the polyethylene or alternately the gypsum board) is continuous at all penetrations through the ceiling. Special care is required to seal around penetrations such as pot lights that generate significant heat. A gypsum board enclosure should be built around all pot light penetrations and the polyethylene and insulation carried over the enclosure. Alternatively, low-wattage, airtight pot lights can be used, in which case the polyethylene is sealed to the pot light housing.

Cavity Ventilation

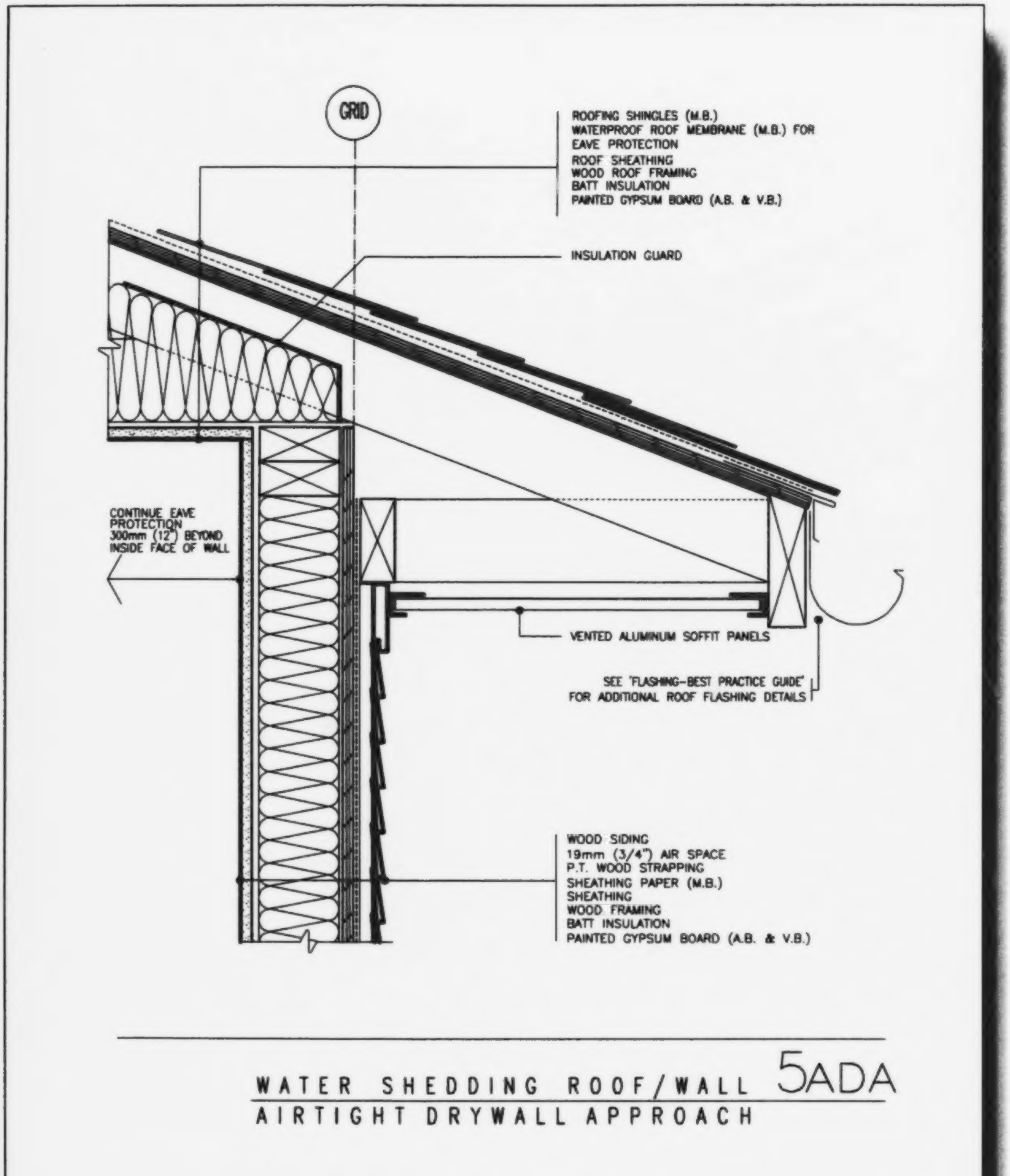
Connecting the wall cavity to the soffit space to allow movement of air between the spaces provides increased drying potential.


GRID
ROOFING SHINGLES (M.B.)
WATERPROOF ROOF MEMBRANE (M.B.) FOR EAVE PROTECTION
ROOF SHEATHING
WOOD ROOF FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD
INSULATION GUARD
POLYETHYLENE (V.B. AND A.B.)
CONTINUE EAVE PROTECTION 300mm (12") BEYOND INSIDE FACE OF WALL
VENTED ALUMINUM SOFFIT PANELS
SEE 'FLASHING-BEST PRACTICE GUIDE' FOR ADDITIONAL ROOF FLASHING DETAILS
VINYL SIDING
19mm (3/4") AIR SPACE
P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD

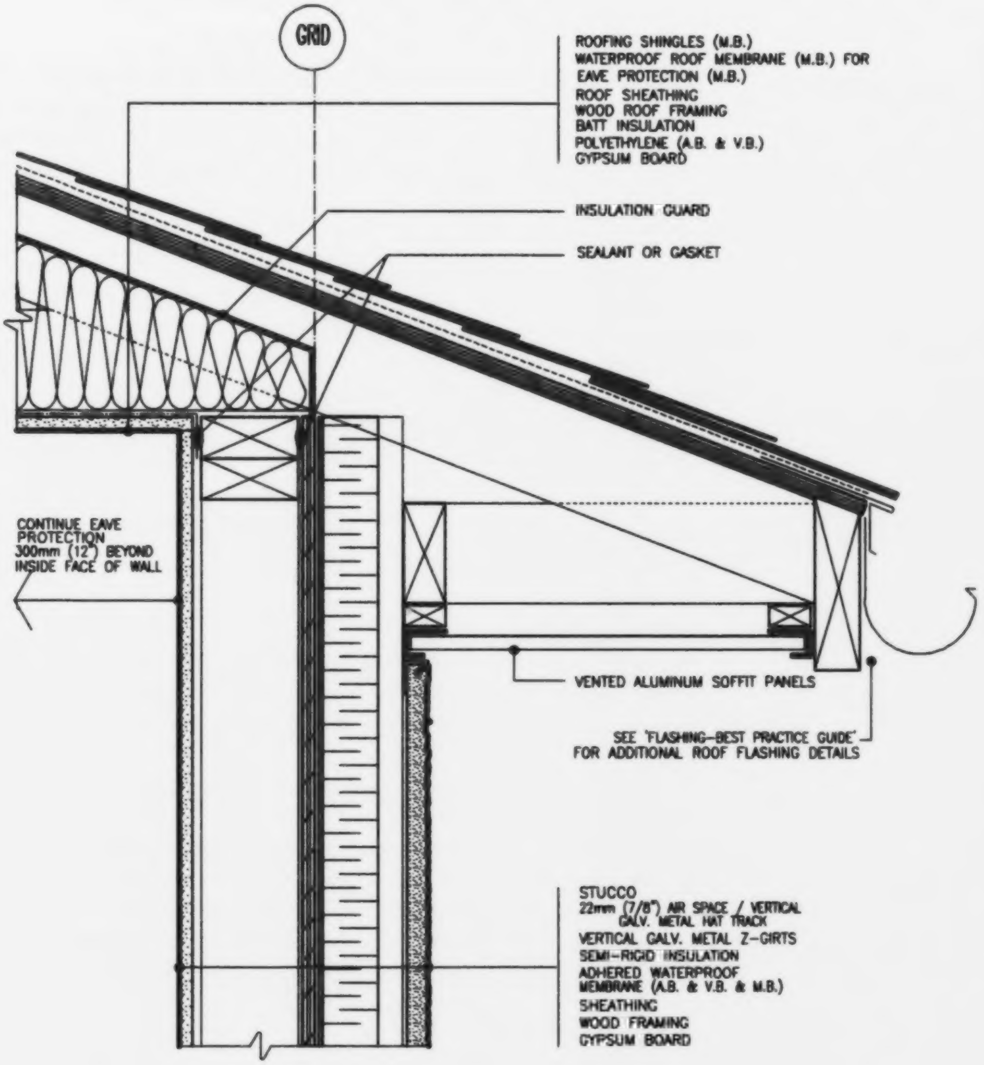
WATER SHEDDING ROOF/WALL 5SPA

SEALED POLYETHYLENE APPROACH

Detail 5 SPA: Water Shedding Roof/Wall–Sealed Polyethylene Approach


GRID
ROOFING SHINGLES (M.B.)
WATERPROOF ROOF MEMBRANE (M.B.) FOR EAVE PROTECTION
ROOF SHEATHING
WOOD ROOF FRAMING
BATT INSULATION
PAINTED GYPSUM BOARD (A.B. & V.B.)
INSULATION GUARD
CONTINUE EAVE PROTECTION 300mm (12") BEYOND INSIDE FACE OF WALL
VENTED ALUMINUM SOFFIT PANELS
SEE 'FLASHING-BEST PRACTICE GUIDE' FOR ADDITIONAL ROOF FLASHING DETAILS
WOOD SIDING
19mm (3/4") AIR SPACE
P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
PAINTED GYPSUM BOARD (A.B. & V.B.)
WATER SHEDDING ROOF/WALL
5ADA
AIRTIGHT DRYWALL APPROACH

Detail 5 ADA: Water Shedding Roof/Wall–Airtight Drywall Approach


GRID
ROOFING SHINGLES (M.B.)
WATERPROOF ROOF MEMBRANE (M.B.) FOR EAVE PROTECTION (M.B.)
ROOF SHEATHING
WOOD ROOF FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD
INSULATION GUARD
SEALANT OR GASKET
CONTINUE EAVE PROTECTION 300mm (12") BEYOND INSIDE FACE OF WALL
VENTED ALUMINUM SOFFIT PANELS
SEE 'FLASHING-BEST PRACTICE GUIDE' FOR ADDITIONAL ROOF FLASHING DETAILS
STUCCO
22mm (7/8") AIR SPACE / VERTICAL GALV. METAL HAT TRACK
VERTICAL GALV. METAL Z-GIRTS
SEMI-RIGID INSULATION
ADHERED WATERPROOF MEMBRANE (A.B. & V.B. & M.B.)
SHEATHING
WOOD FRAMING
GYPSUM BOARD

WATER SHEDDING
ROOF/WALL
5EABA
EXTERIOR AIR BARRIER APPROACH

Detail 5 EABA: *Water Shedding Roof/Wall–Exterior Air Barrier Approach*

DETAIL 6–WATERPROOF MEMBRANE ROOF/WALL

Air Barrier

It is important that the air barrier be continuous under the parapet wall. If the air barrier is not continuous at this location, there is the potential for warm air to leak into the parapet resulting in condensation. It is difficult for moisture to dry from the interior of the parapet because it is not vented.

Roof Drainage

The roof deck has been sloped to drain in this detail. The slope is achieved through the use of cross purlins. Sloping of the roof deck towards the drains allows a constant thickness of insulation to be used throughout the roof system. Tapered insulation is often used to achieve slope to drain when the roof deck is not sloped. The build-up of insulation at the perimeter of the roof and at other locations can result in excess stress in the roof membrane. Also, the use of tapered insulation can result in difficulties in determining door sill heights and curb heights.

Care must be taken to ensure that differential frame shrinkage does not adversely affect the slope to drain.

Alternative Detail

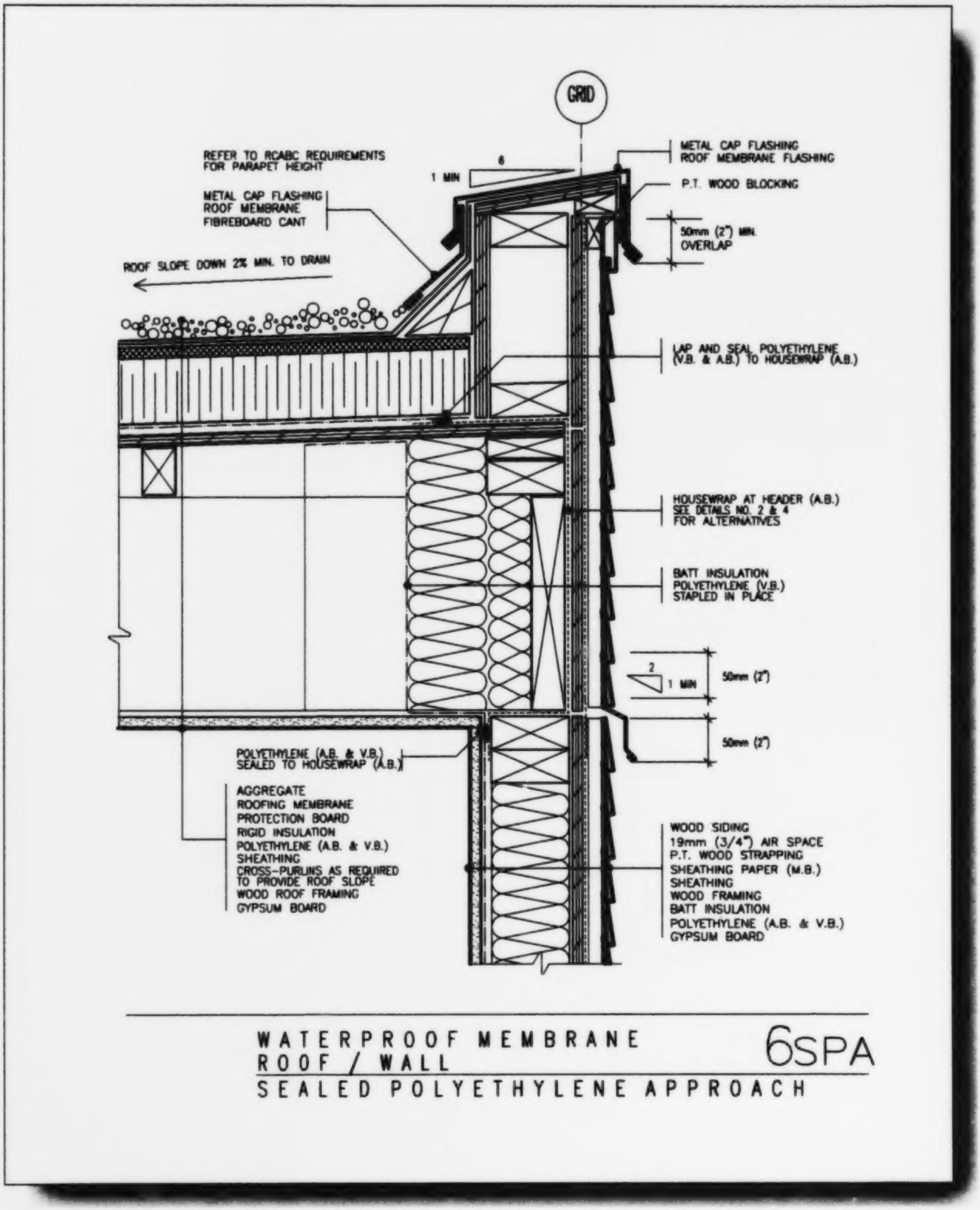
As a second approach, the vapour barrier, insulation and header wrap at the rim joist could be replaced with spray-in-place foam insulation. The use of spray-in-place foam was shown as an alternative approach in Detail 4 (page 6-14).

Cladding Transition Flashing

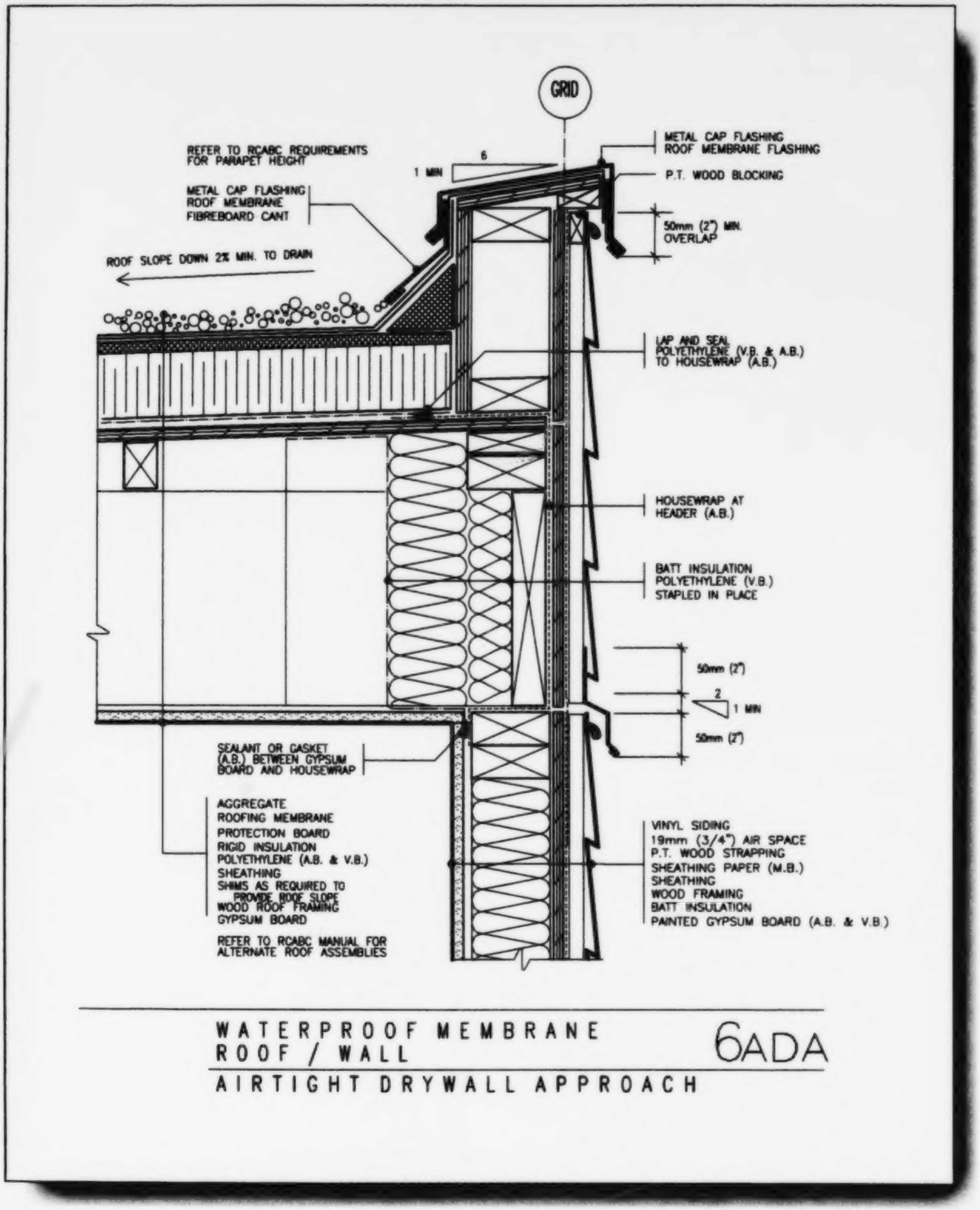
The flashing shown within the cladding at the bottom of the roof joists is intended to provide both a control joint to accommodate frame movement, and a waterproof transition between two sections of cladding. It is not required to be a cross cavity flashing due to the minimal height of wall above. See further discussion of cladding transition flashing with Detail 10.

Parapet Cap Framing

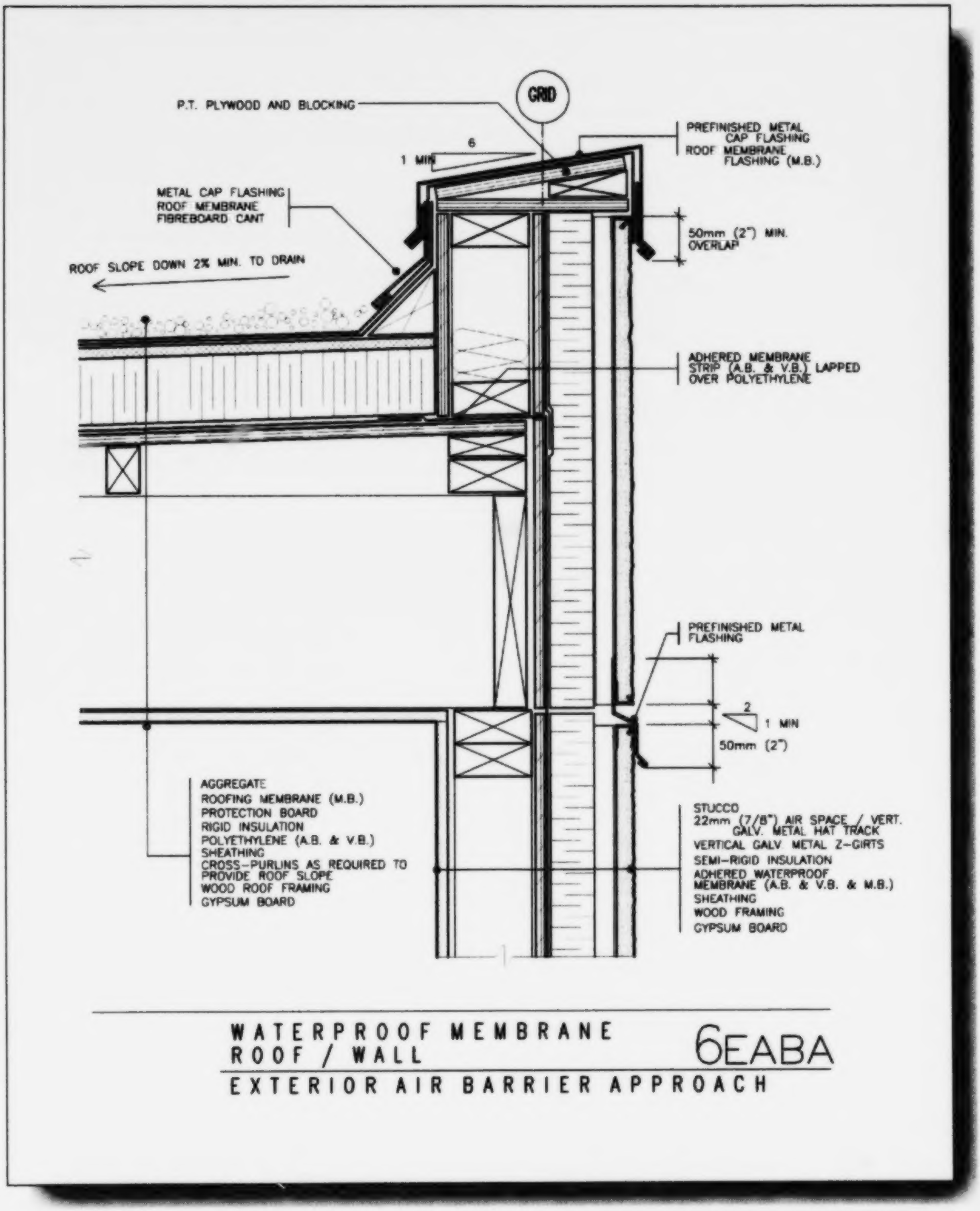
Rather than framing the parapet cap with plywood and shims, a 38 x 184 ripped diagonally could be used.


GRID
REFER TO RCABC REQUIREMENTS FOR PARAPET HEIGHT
1 MIN
6
METAL CAP FLASHING
ROOF MEMBRANE FLASHING
P.T. WOOD BLOCKING
METAL CAP FLASHING
ROOF MEMBRANE
FIBREBOARD CANT
50mm (2") MIN. OVERLAP
ROOF SLOPE DOWN 2% MIN. TO DRAIN
LAP AND SEAL POLYETHYLENE (V.B. & A.B.) TO HOUSEWRAP (A.B.)
HOUSEWRAP AT HEADER (A.B.)
SEE DETAILS NO. 2 & 4
FOR ALTERNATIVES
BATT INSULATION
POLYETHYLENE (V.B.)
STAPLED IN PLACE
2
1 MIN
50mm (2")
50mm (2")
POLYETHYLENE (A.B. & V.B.) SEALED TO HOUSEWRAP (A.B.)
AGGREGATE
ROOFING MEMBRANE
PROTECTION BOARD
RIGID INSULATION
POLYETHYLENE (A.B. & V.B.)
SHEATHING
CROSS-PURLINS AS REQUIRED TO PROVIDE ROOF SLOPE
WOOD ROOF FRAMING
GYPSUM BOARD
WOOD SIDING
19mm (3/4") AIR SPACE
P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD
WATERPROOF MEMBRANE
ROOF / WALL
SEALED POLYETHYLENE APPROACH
6SPA

Detail 6 SPA: Waterproof Membrane Roof/Wall–Sealed Polyethylene Approach


GRID
REFER TO RCABC REQUIREMENTS FOR PARAPET HEIGHT
1 MIN
6
METAL CAP FLASHING
ROOF MEMBRANE
FIBREBOARD CANT
ROOF SLOPE DOWN 2% MIN. TO DRAIN
METAL CAP FLASHING
ROOF MEMBRANE FLASHING
P.T. WOOD BLOCKING
50mm (2") MIN. OVERLAP
LAP AND SEAL POLYETHYLENE (V.B. & A.B.) TO HOUSEWRAP (A.B.)
HOUSEWRAP AT HEADER (A.B.)
BATT INSULATION
POLYETHYLENE (V.B.)
STAPLED IN PLACE
50mm (2")
2
1 MIN
50mm (2")
SEALANT OR GASKET (A.B.) BETWEEN GYPSUM BOARD AND HOUSEWRAP
AGGREGATE
ROOFING MEMBRANE
PROTECTION BOARD
RIGID INSULATION
POLYETHYLENE (A.B. & V.B.)
SHEATHING
SHIMS AS REQUIRED TO PROVIDE ROOF SLOPE
WOOD ROOF FRAMING
GYPSUM BOARD
REFER TO RCABC MANUAL FOR ALTERNATE ROOF ASSEMBLIES
VINYL SIDING
19mm (3/4") AIR SPACE
P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
PAINTED GYPSUM BOARD (A.B. & V.B.)
WATERPROOF MEMBRANE
ROOF / WALL
AIRTIGHT DRYWALL APPROACH
6ADA

Detail 6 ADA: Waterproof Membrane Roof/Wall–Airtight Drywall Approach


GRID
P.T. PLYWOOD AND BLOCKING
1 MIN
6
PREFINISHED METAL CAP FLASHING
ROOF MEMBRANE FLASHING (M.B.)
METAL CAP FLASHING
ROOF MEMBRANE
FIBREBOARD CANT
50mm (2") MIN. OVERLAP
ROOF SLOPE DOWN 2% MIN. TO DRAIN
ADHERED MEMBRANE STRIP (A.B. & V.B.) LAPPED OVER POLYETHYLENE
PREFINISHED METAL FLASHING
2
1 MIN
50mm (2")
AGGREGATE
ROOFING MEMBRANE (M.B.)
PROTECTION BOARD
RIGID INSULATION
POLYETHYLENE (A.B. & V.B.)
SHEATHING
CROSS-PURLINS AS REQUIRED TO PROVIDE ROOF SLOPE
WOOD ROOF FRAMING
GYPSUM BOARD
STUCCO
22mm (7/8") AIR SPACE / VERT. GALV. METAL HAT TRACK
VERTICAL GALV METAL Z-GIRTS
SEMI-RIGID INSULATION
ADHERED WATERPROOF MEMBRANE (A.B. & V.B. & M.B.)
SHEATHING
WOOD FRAMING
GYPSUM BOARD
WATERPROOF MEMBRANE
ROOF / WALL
6EABA
EXTERIOR AIR BARRIER APPROACH

Detail 6 EABA: Waterproof Membrane Roof/Wall–Exterior Air Barrier Approach

DETAIL 7–CANTILEVERED FLOOR

Cavity Ventilation

Connect the wall cavity to the soffit space to allow movement of air between the spaces. This provides increased drying potential at a protected location.

Alternative Detail

As a second approach, the vapour barrier, insulation and header wrap at the cantilevered floor could be replaced with spray-in-place foam insulation.

Airtight Drywall Approach

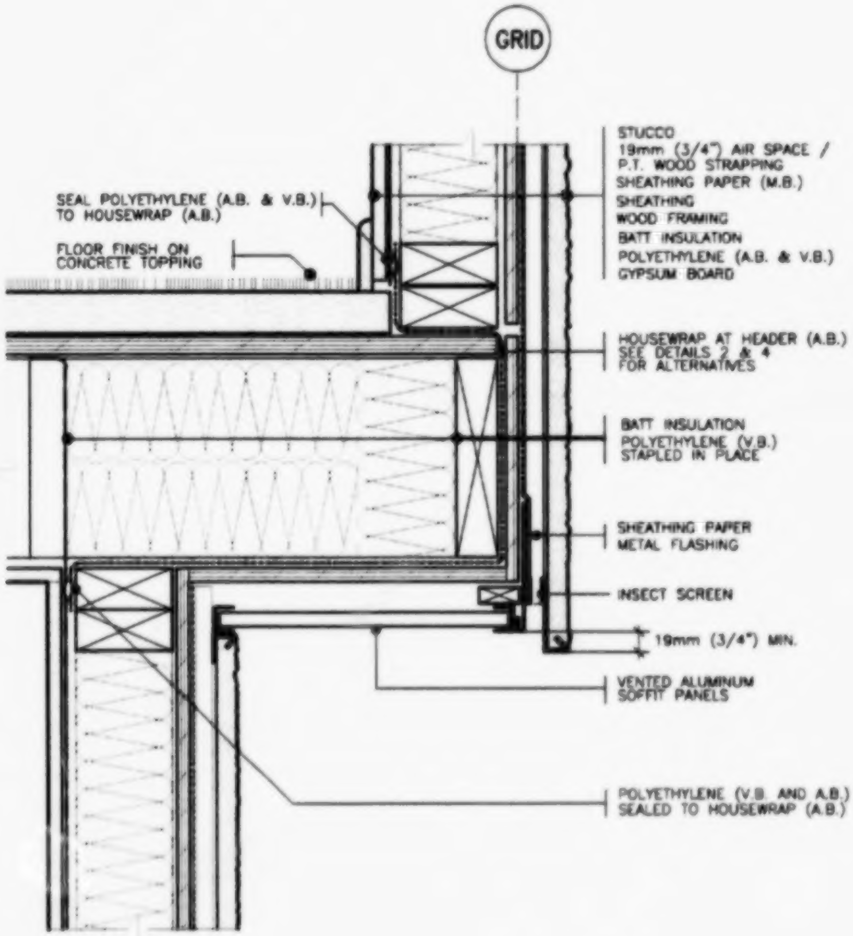
The method of providing air barrier continuity is similar to that shown in the sealed polyethylene approach and is achieved through the use of housewrap at the header connected to the wall plates above and below.

Exterior Air Barrier Approach

Construction of the detail using the exterior air barrier approach is easier as the insulation between the joists, the polyethylene vapour barrier, sealants and gaskets are omitted.

Fire Separation

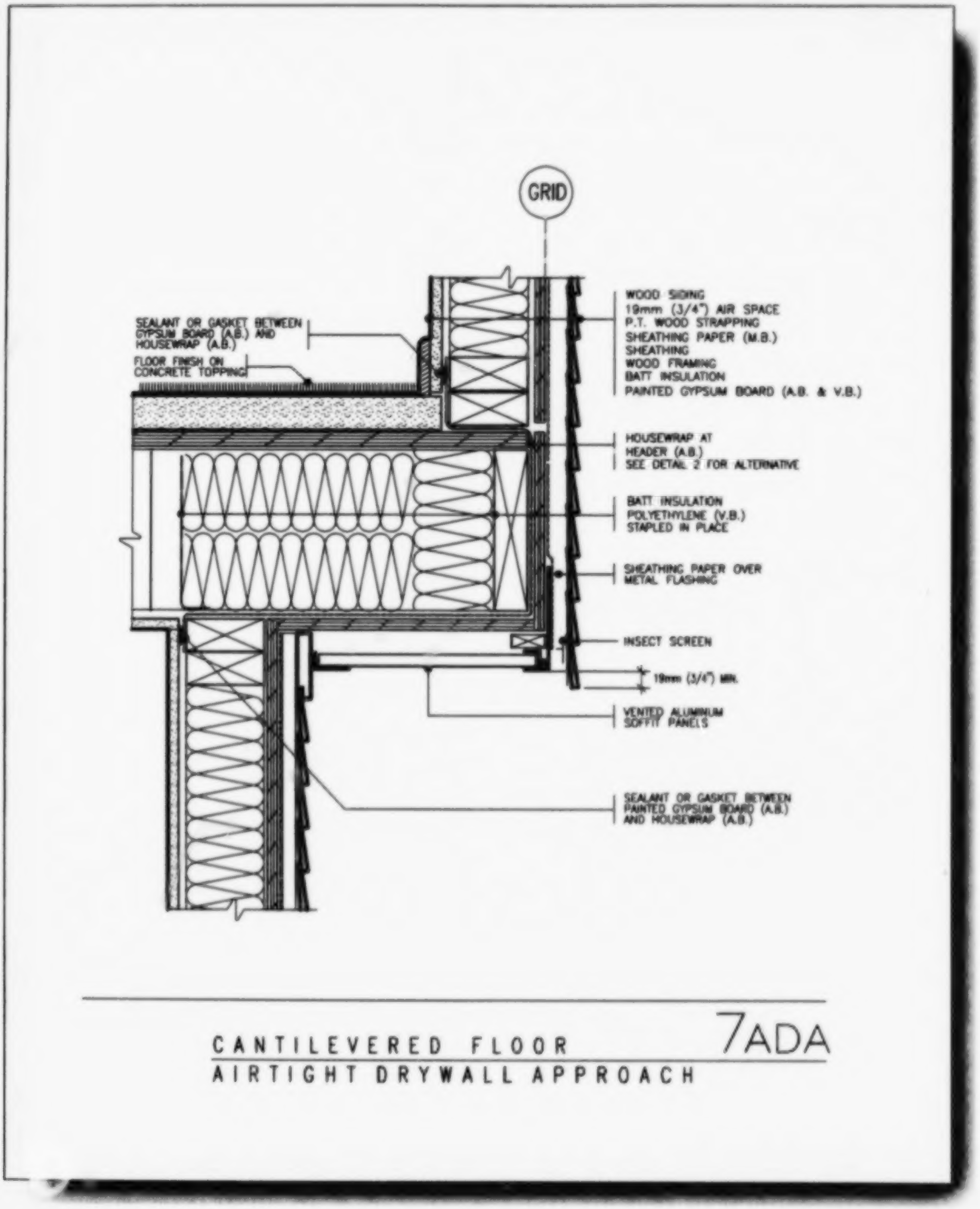
Exterior gypsum board is required at the soffit if the floor is a fire separation.


GRID
STUCCO
19mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD
SEAL POLYETHYLENE (A.B. & V.B.) TO HOUSEWRAP (A.B.)
FLOOR FINISH ON CONCRETE TOPPING
HOUSEWRAP AT HEADER (A.B.) SEE DETAILS 2 & 4 FOR ALTERNATIVES
BATT INSULATION
POLYETHYLENE (V.B.) STAPLED IN PLACE
SHEATHING PAPER
METAL FLASHING
INSECT SCREEN
19mm (3/4") MIN.
VENTED ALUMINUM SOFFIT PANELS
POLYETHYLENE (V.B. AND A.B.) SEALED TO HOUSEWRAP (A.B.)

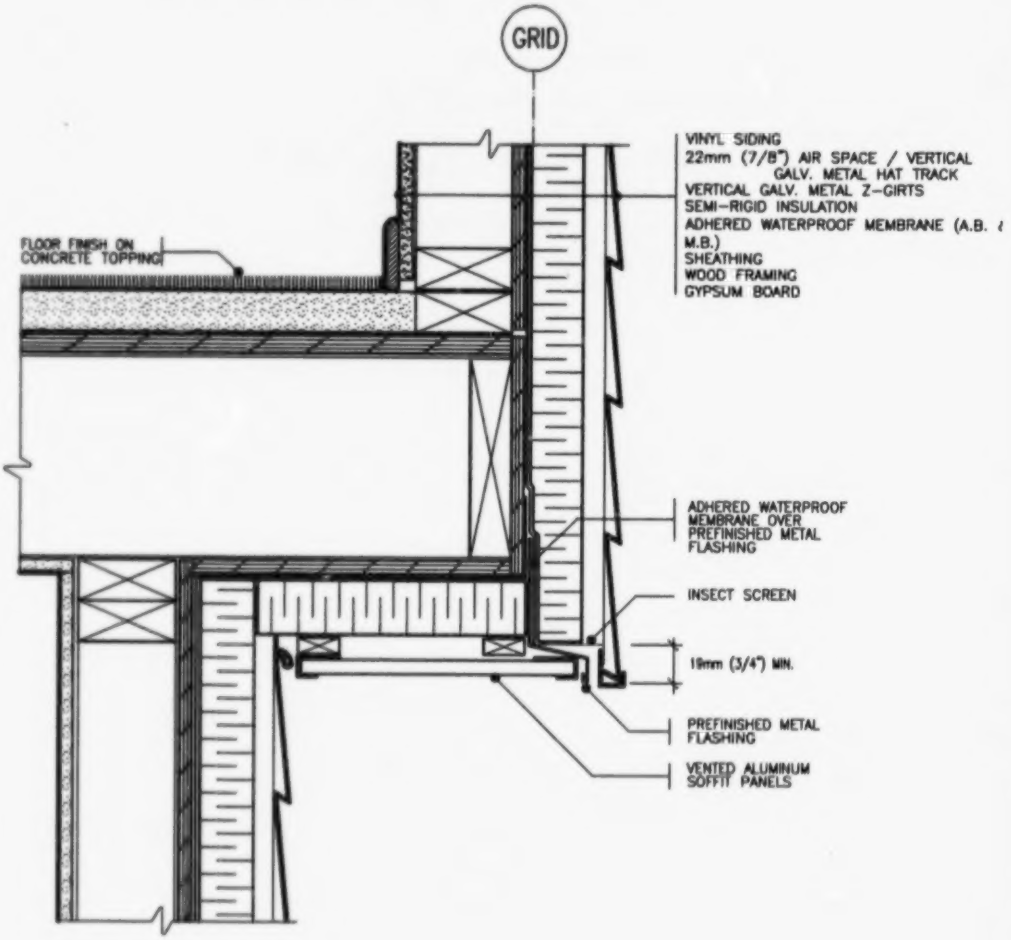
CANTILEVERED FLOOR 7SPA

SEALED POLYETHYLENE APPROACH

Detail 7 SPA: Cantilevered Floor–Sealed Polyethylene Approach


GRID
SEALANT OR GASKET BETWEEN GYPSUM BOARD (A.B.) AND HOUSEWRAP (A.B.)
FLOOR FINISH ON CONCRETE TOPPING
WOOD SIDING
19mm (3/4") AIR SPACE
P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
PAINTED GYPSUM BOARD (A.B. & V.B.)
HOUSEWRAP AT HEADER (A.B.)
SEE DETAIL 2 FOR ALTERNATIVE
BATT INSULATION
POLYETHYLENE (V.B.) STAPLED IN PLACE
SHEATHING PAPER OVER METAL FLASHING
INSECT SCREEN
19mm (3/4") MIN.
VENTED ALUMINUM SOFFIT PANELS
SEALANT OR GASKET BETWEEN PAINTED GYPSUM BOARD (A.B.) AND HOUSEWRAP (A.B.)
CANTILEVERED FLOOR
AIRTIGHT DRYWALL APPROACH
7ADA

Detail 7 ADA: Cantilevered Floor–Airtight Drywall Approach


GRID
VINYL SIDING
22mm (7/8") AIR SPACE / VERTICAL GALV. METAL HAT TRACK
VERTICAL GALV. METAL Z-GIRTS
SEMI-RIGID INSULATION
ADHERED WATERPROOF MEMBRANE (A.B.
M.B.)
SHEATHING
WOOD FRAMING
GYPSUM BOARD
FLOOR FINISH ON CONCRETE TOPPING
ADHERED WATERPROOF MEMBRANE OVER PREFINISHED METAL FLASHING
INSECT SCREEN
19mm (3/4") MIN.
PREFINISHED METAL FLASHING
VENTED ALUMINUM SOFFIT PANELS

CANTILEVERED FLOOR 7EABA

EXTERIOR AIR BARRIER APPROACH

Detail 7 EABA: Cantilevered Floor–Exterior Air Barrier Approach

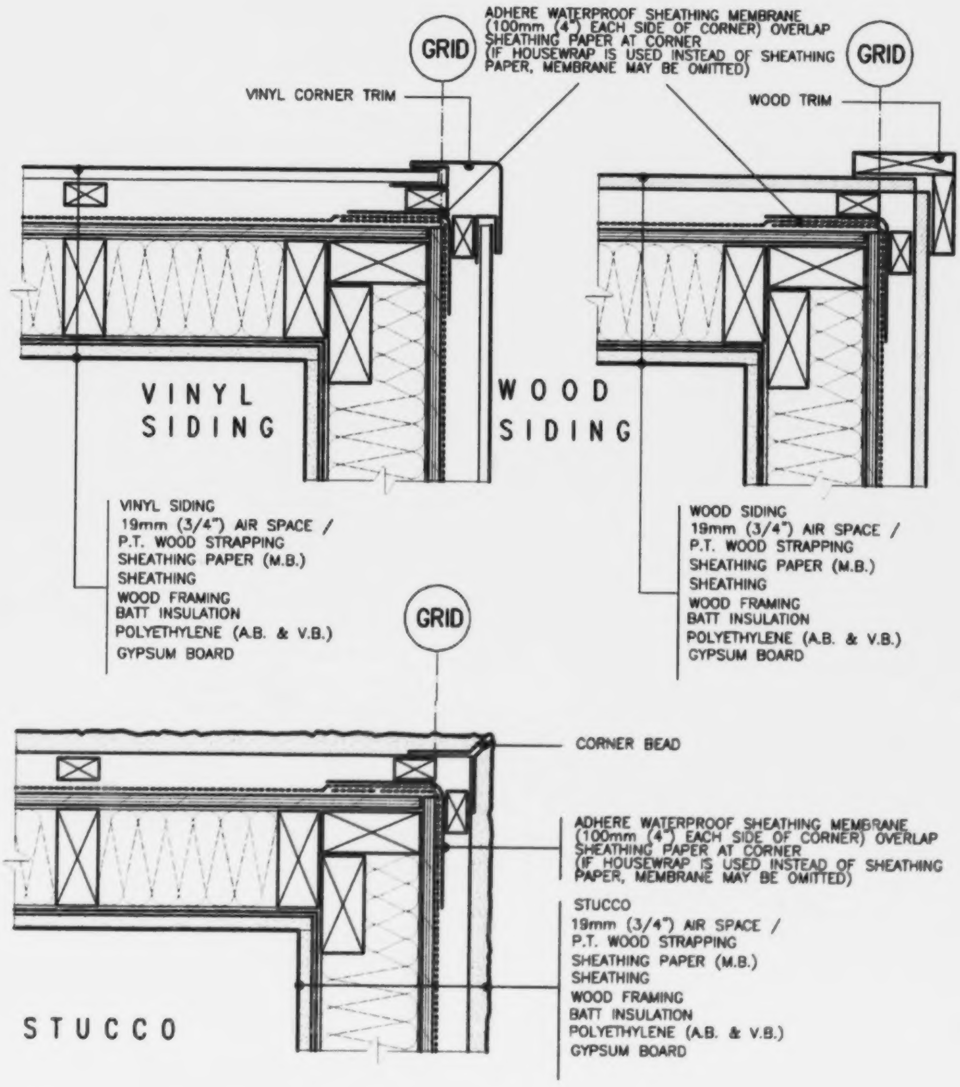
DETAIL 8–EXTERIOR CORNER

Strapping at Corner

Note that a cavity is shown between the two strapping sections at the corner. It is important that there be a cavity because corners are one of the most probable locations for water to penetrate past the cladding.

Sheathing Membrane

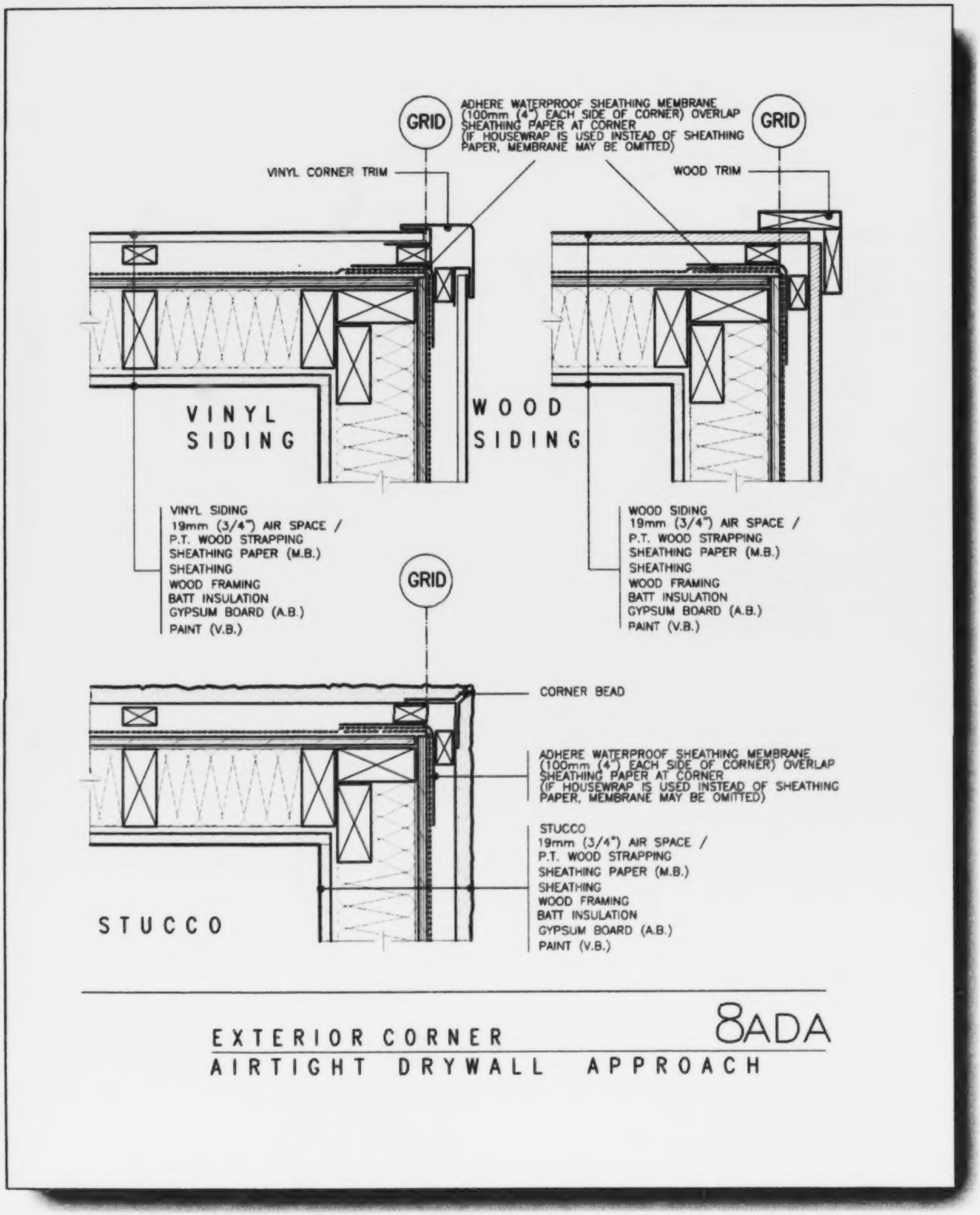
Adhered waterproof sheathing membrane is shown over top of the sheathing paper at the outside corner. The membrane is used to provide additional protection at corners as it is more resistant to damage during construction. Since housewrap is more resistant to damage and cracking than sheathing paper, the waterproof membrane may be omitted if housewrap is used instead of sheathing paper.


GRID
ADHERE WATERPROOF SHEATHING MEMBRANE (100mm (4") EACH SIDE OF CORNER) OVERLAP SHEATHING PAPER AT CORNER (IF HOUSEWRAP IS USED INSTEAD OF SHEATHING PAPER, MEMBRANE MAY BE OMITTED)
GRID
VINYL CORNER TRIM
WOOD TRIM
VINYL SIDING
WOOD SIDING
VINYL SIDING
19mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD
WOOD SIDING
19mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD
GRID
CORNER BEAD
ADHERE WATERPROOF SHEATHING MEMBRANE (100mm (4") EACH SIDE OF CORNER) OVERLAP SHEATHING PAPER AT CORNER (IF HOUSEWRAP IS USED INSTEAD OF SHEATHING PAPER, MEMBRANE MAY BE OMITTED)
STUCCO
19mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD
STUCCO

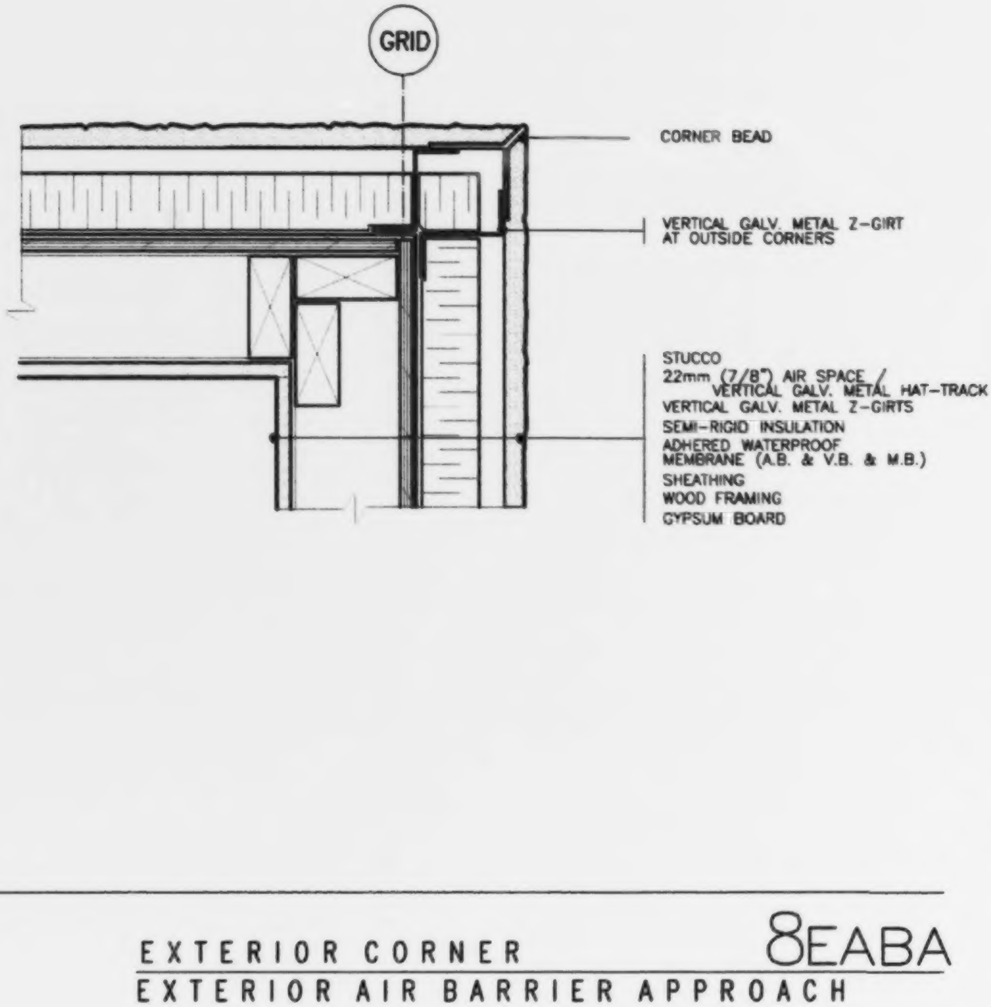
EXTERIOR CORNER 8SPA

SEALED POLYETHYLENE APPROACH

Detail 8 SPA: Exterior Corner–Sealed Polyethylene Approach


GRID
ADHERE WATERPROOF SHEATHING MEMBRANE (100mm (4") EACH SIDE OF CORNER) OVERLAP SHEATHING PAPER AT CORNER (IF HOUSEWRAP IS USED INSTEAD OF SHEATHING PAPER, MEMBRANE MAY BE OMITTED)
GRID
VINYL CORNER TRIM
WOOD TRIM
VINYL SIDING
WOOD SIDING
VINYL SIDING
19mm (3/4") AIR SPACE /
P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
GYPSUM BOARD (A.B.)
PAINT (V.B.)
WOOD SIDING
19mm (3/4") AIR SPACE /
P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
GYPSUM BOARD (A.B.)
PAINT (V.B.)
GRID
CORNER BEAD
ADHERE WATERPROOF SHEATHING MEMBRANE (100mm (4") EACH SIDE OF CORNER) OVERLAP SHEATHING PAPER AT CORNER (IF HOUSEWRAP IS USED INSTEAD OF SHEATHING PAPER, MEMBRANE MAY BE OMITTED)
STUCCO
STUCCO
19mm (3/4") AIR SPACE /
P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
GYPSUM BOARD (A.B.)
PAINT (V.B.)
EXTERIOR CORNER
AIRTIGHT DRYWALL APPROACH
8ADA

***Detail 8 ADA:** Exterior Corner–Airtight Drywall Approach*


GRID
CORNER BEAD
VERTICAL GALV. METAL Z-GIRT AT OUTSIDE CORNERS
STUCCO
22mm (7/8") AIR SPACE / VERTICAL GALV. METAL HAT-TRACK
VERTICAL GALV. METAL Z-GIRTS
SEMI-RIGID INSULATION
ADHERED WATERPROOF MEMBRANE (A.B. & V.B. & M.B.)
SHEATHING
WOOD FRAMING
GYPSUM BOARD
EXTERIOR CORNER
EXTERIOR AIR BARRIER APPROACH
8EABA

Detail 8 EABA: Exterior Corner–Exterior Air Barrier Approach

DETAIL 9–INTERIOR CORNER

Strapping at Corner

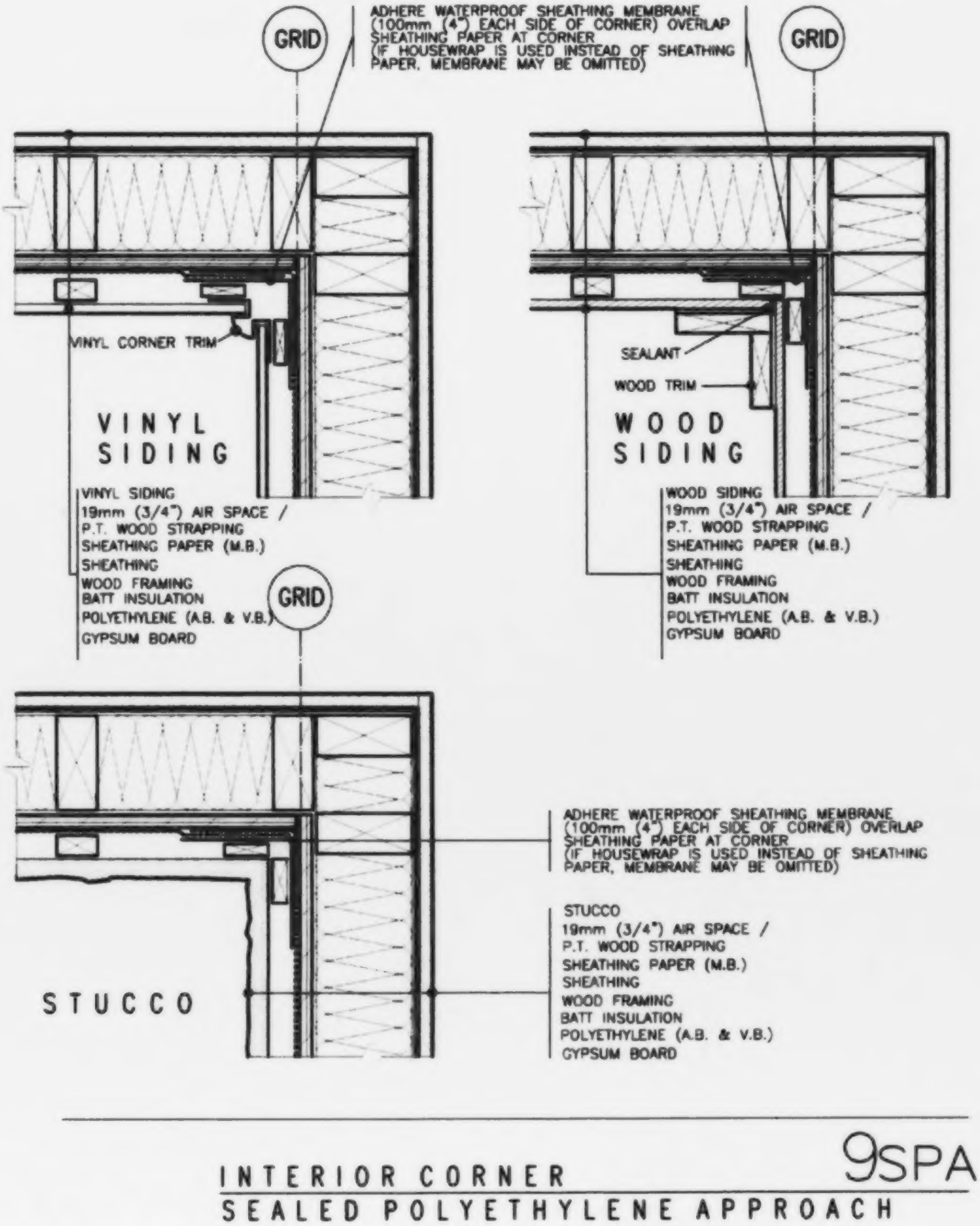
Note that a cavity is shown between the two strapping sections at the corner. It is important that there be a cavity because corners are one of the most probable locations for water to penetrate past the cladding.

Sheathing Membrane

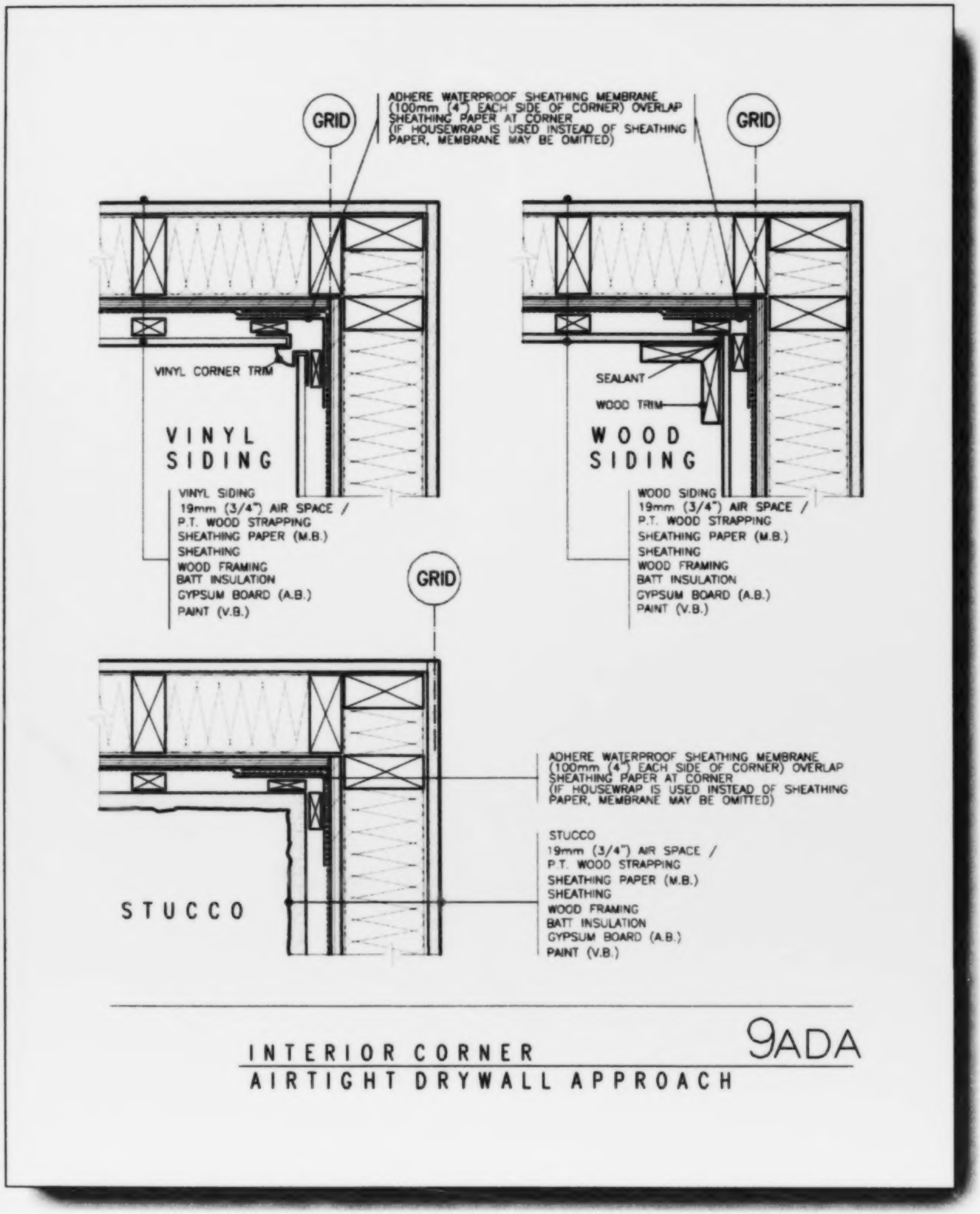
Adhered waterproof sheathing membrane is shown over top of the sheathing paper at the outside corner. The membrane is used to provide additional protection at corners as it is more resistant to damage during construction. Since housewrap is more resistant to damage and cracking than sheathing paper, the waterproof membrane may be omitted if housewrap is used instead of sheathing paper.

Vinyl Siding

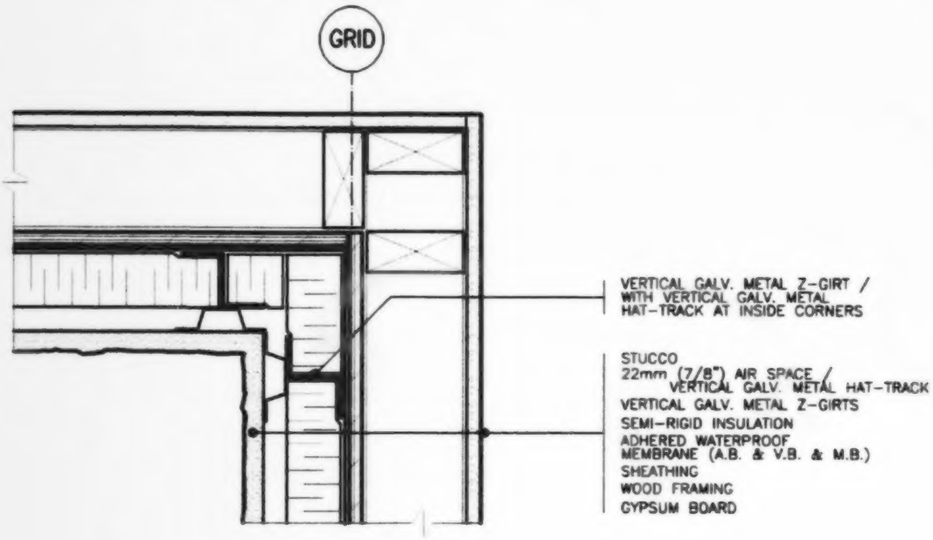
Note that a prefabricated vinyl inside corner section is shown. Back-to-back J-molds are often used to form inside corners but this is not recommended practice.


GRID
ADHERE WATERPROOF SHEATHING MEMBRANE (100mm (4") EACH SIDE OF CORNER) OVERLAP SHEATHING PAPER AT CORNER (IF HOUSEWRAP IS USED INSTEAD OF SHEATHING PAPER, MEMBRANE MAY BE OMITTED)
GRID
VINYL CORNER TRIM
VINYL SIDING
VINYL SIDING
19mm (3/4") AIR SPACE /
P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD
SEALANT
WOOD TRIM
WOOD SIDING
WOOD SIDING
19mm (3/4") AIR SPACE /
P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD
GRID
ADHERE WATERPROOF SHEATHING MEMBRANE (100mm (4") EACH SIDE OF CORNER) OVERLAP SHEATHING PAPER AT CORNER (IF HOUSEWRAP IS USED INSTEAD OF SHEATHING PAPER, MEMBRANE MAY BE OMITTED)
STUCCO
STUCCO
19mm (3/4") AIR SPACE /
P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD
INTERIOR CORNER
SEALED POLYETHYLENE APPROACH
9SPA

Detail 9 SPA: Interior Corner–Sealed Polyethylene Approach


GRID
ADHERE WATERPROOF SHEATHING MEMBRANE (100mm (4") EACH SIDE OF CORNER) OVERLAP SHEATHING PAPER AT CORNER (IF HOUSEWRAP IS USED INSTEAD OF SHEATHING PAPER, MEMBRANE MAY BE OMITTED)
GRID
VINYL CORNER TRIM
VINYL SIDING
VINYL SIDING
19mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
GYPSUM BOARD (A.B.)
PAINT (V.B.)
SEALANT
WOOD TRIM
WOOD SIDING
WOOD SIDING
19mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
GYPSUM BOARD (A.B.)
PAINT (V.B.)
GRID
ADHERE WATERPROOF SHEATHING MEMBRANE (100mm (4") EACH SIDE OF CORNER) OVERLAP SHEATHING PAPER AT CORNER (IF HOUSEWRAP IS USED INSTEAD OF SHEATHING PAPER, MEMBRANE MAY BE OMITTED)
STUCCO
STUCCO
19mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
GYPSUM BOARD (A.B.)
PAINT (V.B.)
INTERIOR CORNER
AIRTIGHT DRYWALL APPROACH
9ADA

Detail 9 ADA: Interior Corner–Airtight Drywall Approach


GRID
VERTICAL GALV. METAL Z-GIRT / WITH VERTICAL GALV. METAL HAT-TRACK AT INSIDE CORNERS
STUCCO
22mm (7/8") AIR SPACE / VERTICAL GALV. METAL HAT-TRACK
VERTICAL GALV. METAL Z-GIRTS
SEMI-RIGID INSULATION
ADHERED WATERPROOF MEMBRANE (A.B. & V.B. & M.B.)
SHEATHING
WOOD FRAMING
GYPSUM BOARD

INTERIOR CORNER 9EABA
EXTERIOR AIR BARRIER APPROACH

Detail 9 EABA: Interior Corner–Exterior Air Barrier Approach

DETAIL 10–CLADDING TRANSITION

Transition Flashing

The joints in the transition flashing should be designed and constructed to minimize the potential for water penetration. Joints at inside and outside corners should be standing seam. Joints in the straight run sections should be S-lock. Using a 2:1 slope on the flashing reduces the potential for water to leak through the joints.

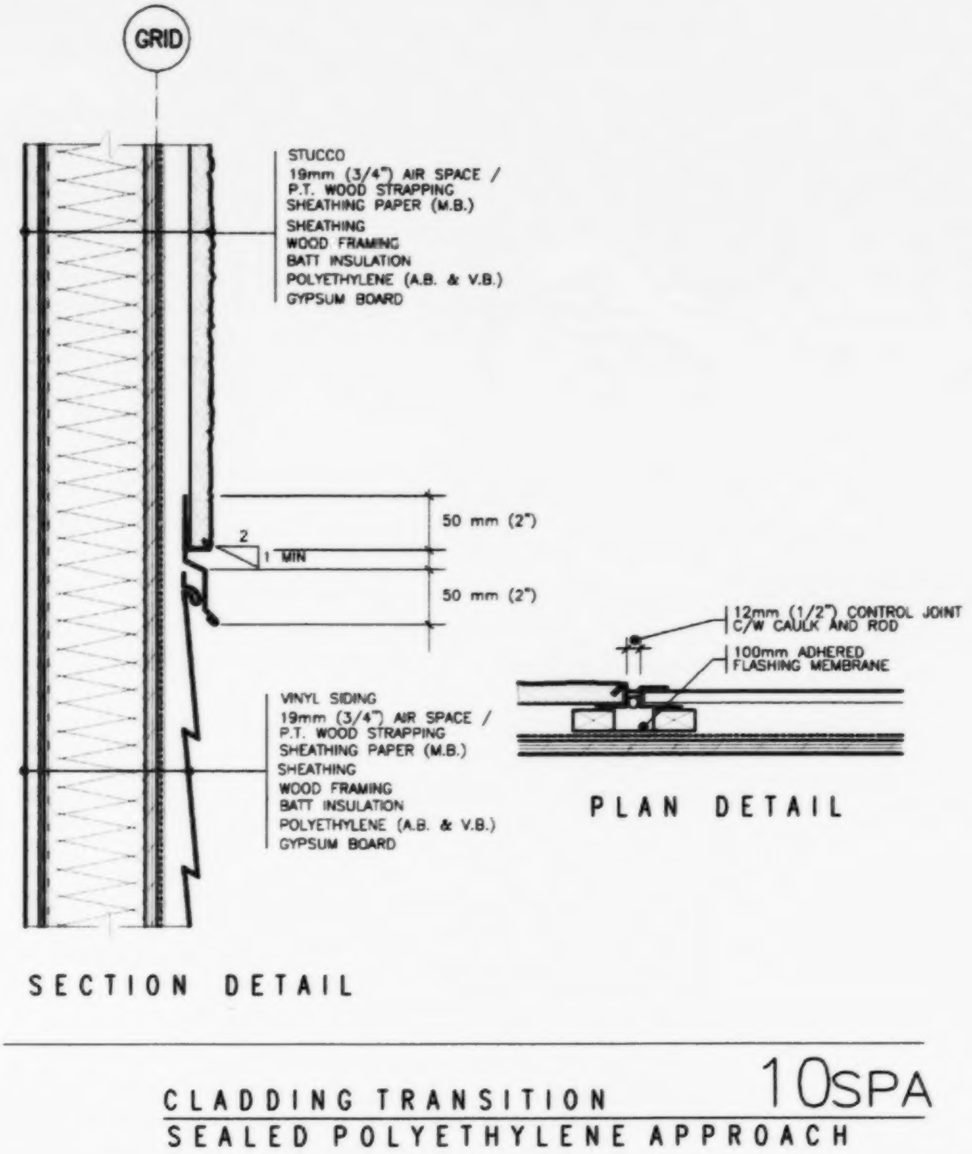
Material transitions will often occur at floor lines. In this case, a cross-cavity flashing described in Detail 4 (page 6-14) would be used.

Transitions Between Materials

Note that the termination detail for each of the cladding materials is supported on a separate strap. It is important that a cavity be present behind the sealant joint to allow drainage of any water that penetrates past the sealant.

Widths of horizontal joints should be calculated. The required joint width will depend on the coefficient of thermal expansion of the adjacent materials, the size of the panels, the temperature extremes the cladding will be subjected to and the ambient temperature at the time of sealant application.

A strip of adhered waterproof sheathing membrane is applied on top of the sheathing paper at the joint location. The membrane will reduce the potential for water ingress if the sealant in the joint is not maintained.


GRID
STUCCO
19mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD
50 mm (2")
2
1 MIN
50 mm (2")
12mm (1/2") CONTROL JOINT C/W CAULK AND ROD
100mm ADHERED FLASHING MEMBRANE
VINYL SIDING
19mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD
PLAN DETAIL
SECTION DETAIL
CLADDING TRANSITION
10SPA
SEALED POLYETHYLENE APPROACH

Detail 10 SPA: Cladding Transition–Sealed Polyethylene Approach

DETAIL 11–WINDOW HEAD

Head Flashing

The head flashing should extend 25 mm beyond the window jamb. To prevent water running off the end of the flashing and entering the cavity, the head flashing incorporates an end dam. At this location the cladding must be cut to fit around the projection of the flashing and the end dam.

Detailing of the window with the nail-on flange placed to the exterior of the pressure treated strapping may cause problems at the window head because there will be insufficient space between the nail-on flange and the cladding to allow for drainage.

Air Barrier

Air barrier continuity is maintained by sealing the joint between the window frame and the sheathing paper, which returns into the rough opening. The sheathing paper is in turn sealed to the polyethylene vapour barrier. This approach can work well if a housewrap type sheathing paper is used. If building paper is used it may will be necessary to identify an alternate approach since building paper is not an ideal air barrier material.

Airtight Drywall Approach

Air barrier continuity is maintained by sealing the joint between the window frame and the adhered membrane, which wraps the rough opening. The gypsum board is then sealed to the membrane.

Exterior Air Barrier Approach

Air barrier continuity is maintained by sealing the joint between the window frame and the adhered waterproof membrane, which returns into the rough opening.

Care must be taken in all cases when detailing and dimensioning the head flashing to ensure that it does not restrict opening of the window.

The complete installation of a head-jamb detail, and a sill-jamb detail are illustrated of pages 6-88 and 6-89 respectively.

Renewals

When using flange type windows consideration should be given to the need for replacement of the windows prior to requiring cladding replacement. Cost effective renewals could be facilitated through the use of a removable perimeter band detail. Alternately, rebate or box type window frame sections can generally be replaced with minimal disruption to the cladding.

Use of Adhered Membrane

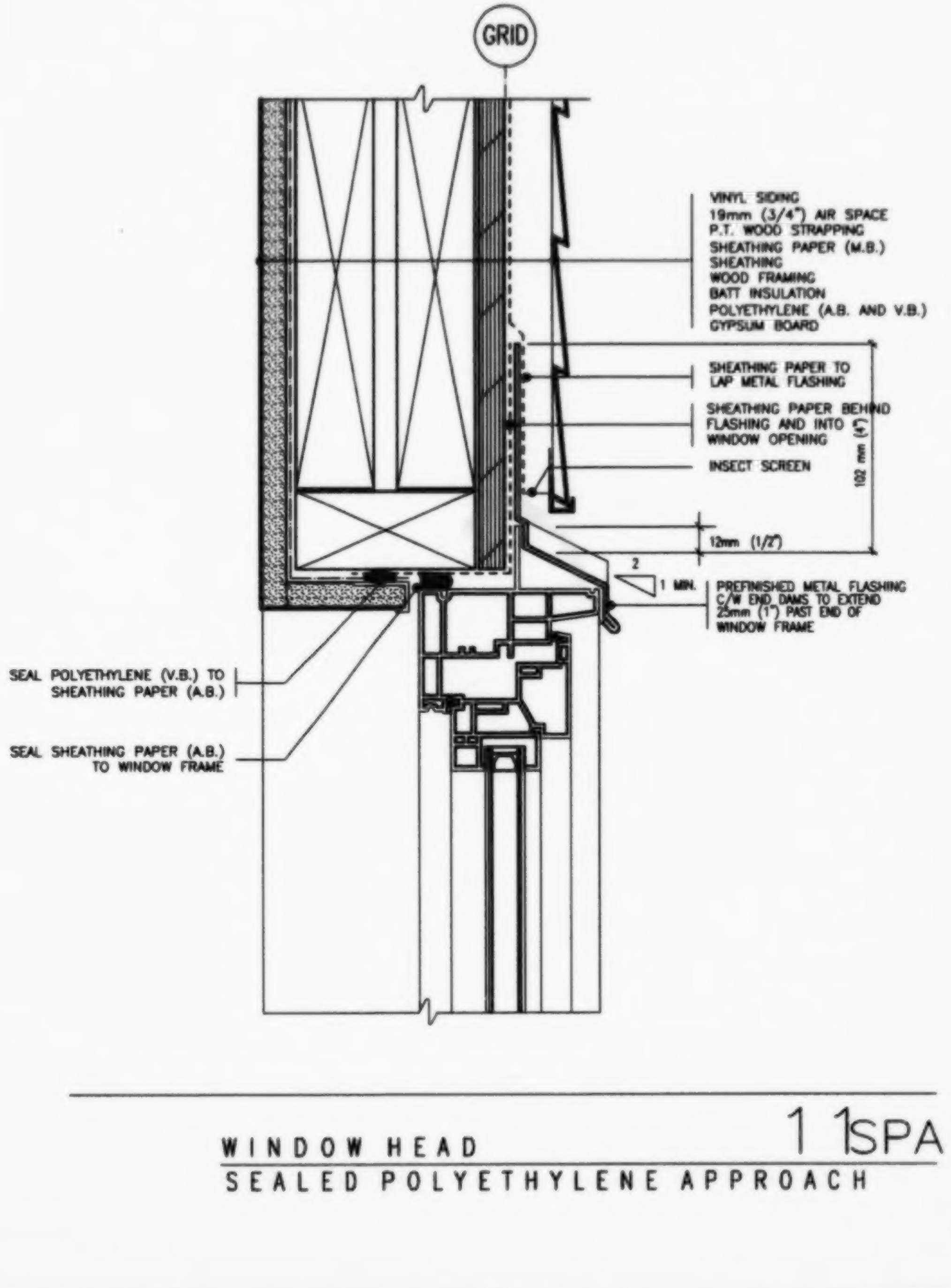
The use of excessive amounts of adhered membrane should be avoided particularly at locations that would tend to trap the vertical downward migration of any moisture present. The presence of adhered membrane and polyethylene creates a vapour impermeable pocket from which it is very difficult for any incidental moisture to dry. Therefore, while the use of adhered membrane is advisable at the window sills, and at least part way up the window jambs, its use at window heads should be avoided.

Framing

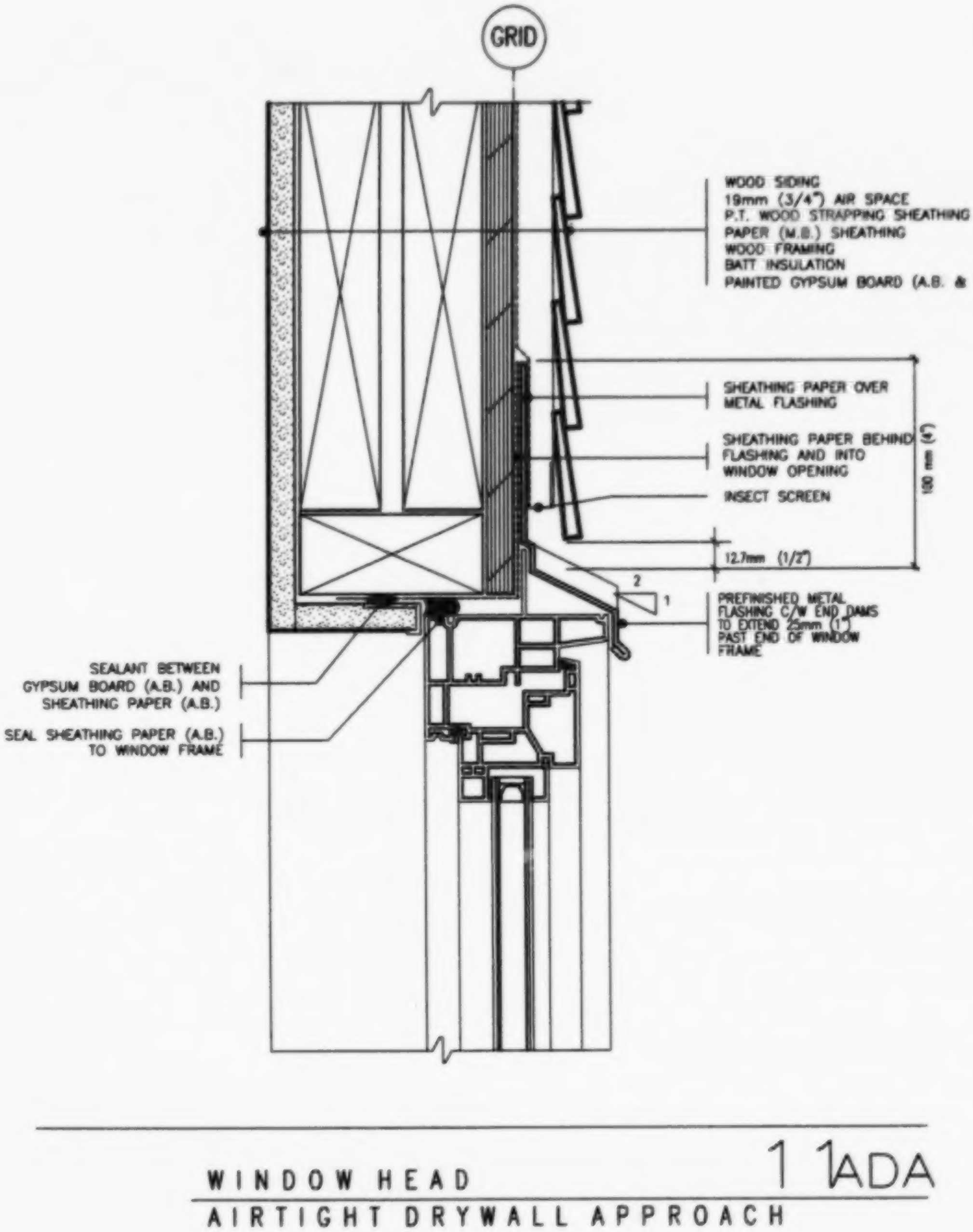
It is not always necessary to have solid framing above a window opening. The use of the rim joist above or a box beam can provide a less dense framing arrangement that may dry more easily. It is also possible to locate plywood spacers or shims between two headers to create an air space and more effective drying.

Allowance for Shrinkage

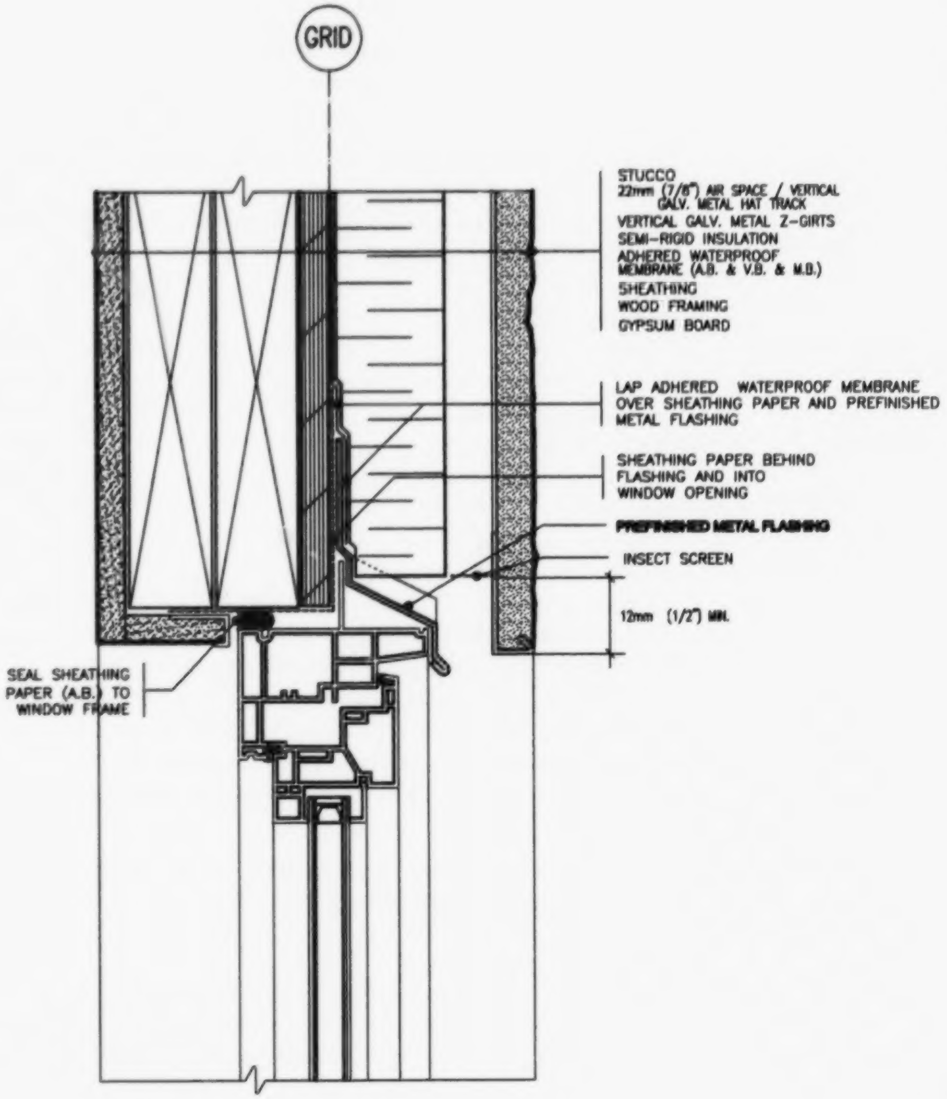
Allowances must be made at the window perimeter for frame shrinkage so that vertical loads from the frame are not transferred to the window unit. The use of high modulus sealants at the window perimeter may transfer excessive loads.


GRID
VINYL SIDING
19mm (3/4") AIR SPACE
P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. AND V.B.)
GYPSUM BOARD
SHEATHING PAPER TO LAP METAL FLASHING
SHEATHING PAPER BEHIND FLASHING AND INTO WINDOW OPENING
102 mm (4")
INSECT SCREEN
12mm (1/2")
2
1 MIN.
PREFINISHED METAL FLASHING C/W END DAMS TO EXTEND 25mm (1") PAST END OF WINDOW FRAME
SEAL POLYETHYLENE (V.B.) TO SHEATHING PAPER (A.B.)
SEAL SHEATHING PAPER (A.B.) TO WINDOW FRAME
WINDOW HEAD
11SPA
SEALED POLYETHYLENE APPROACH

Detail 11 SPA: Window Head–Sealed Polyethylene Approach


GRID
WOOD SIDING
19mm (3/4") AIR SPACE
P.T. WOOD STRAPPING SHEATHING
PAPER (M.B.) SHEATHING
WOOD FRAMING
BATT INSULATION
PAINTED GYPSUM BOARD (A.B. & V.B.)
SHEATHING PAPER OVER METAL FLASHING
SHEATHING PAPER BEHIND FLASHING AND INTO WINDOW OPENING
INSECT SCREEN
100 mm (4")
12.7mm (1/2")
2
1
PREFINISHED METAL FLASHING C/W END DAMS TO EXTEND 25mm (1") PAST END OF WINDOW FRAME
SEALANT BETWEEN GYPSUM BOARD (A.B.) AND SHEATHING PAPER (A.B.)
SEAL SHEATHING PAPER (A.B.) TO WINDOW FRAME
WINDOW HEAD
11ADA
AIRTIGHT DRYWALL APPROACH

Detail 11 ADA: Window Head–Airtight Drywall Approach


GRID
STUCCO
22mm (7/8") AIR SPACE / VERTICAL GALV. METAL HAT TRACK
VERTICAL GALV. METAL Z-GIRTS
SEMI-RIGID INSULATION
ADHERED WATERPROOF MEMBRANE (A.B. & V.B. & M.B.)
SHEATHING
WOOD FRAMING
GYPSUM BOARD
LAP ADHERED WATERPROOF MEMBRANE OVER SHEATHING PAPER AND PREFINISHED METAL FLASHING
SHEATHING PAPER BEHIND FLASHING AND INTO WINDOW OPENING
PREFINISHED METAL FLASHING
INSECT SCREEN
12mm (1/2") MIN.
SEAL SHEATHING PAPER (A.B.) TO WINDOW FRAME

WINDOW HEAD 11EABA

EXTERIOR AIR BARRIER APPROACH

Detail 11 EABA: Window Head–Exterior Air Barrier Approach

DETAIL 12–WINDOW JAMB

Window Placement
Note that the window frame has a 'bull nose' specifically fabricated for use with a 19 mm air space. If this type of frame is not available, a specialty flashing may be required at the window jambs for closure of the cavity.

Detailing of the window with the nail-on flange placed to the exterior of the pressure-treated strap at the jamb may cause problems at the window head because there will be insufficient space between the nail-on flange and the cladding to allow for drainage.

Thermal Movement
A properly configured sealant joint is required between the cladding and the window frame to accommodate the differential movement between these two elements; vinyl windows have a significantly larger coefficient of thermal expansion than many of the commonly used claddings. Properly configured sealant joints are easier to replace than the fillet beads that have commonly been used.

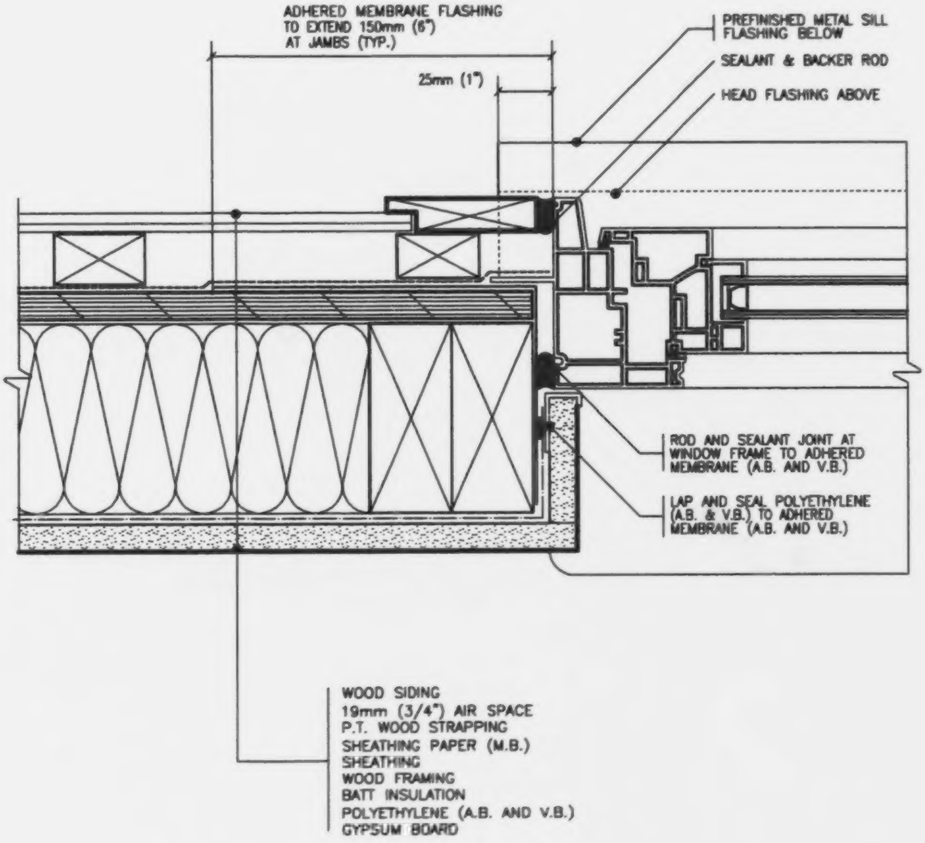
Airtight Drywall Approach
Air barrier continuity is maintained by sealing the joint between the window frame and the adhered membrane, which wraps around the rough opening. The gypsum board is then sealed to the membrane.

Exterior Air Barrier Approach
Air barrier continuity is maintained by sealing the joint between the window frame and the adhered waterproof membrane, which returns into the rough opening.

The complete installation of a head-jamb detail, and a sill-jamb detail are illustrated of pages 6-88 and 6-89 respectively.

Renewals
When using flange type windows consideration should be given to the need for replacement of the windows prior to requiring cladding replacement. Cost effective renewals could be facilitated through the use of a removable perimeter band detail. Alternately, rebate or box type window frame sections can generally be replaced with minimal disruption to the cladding.

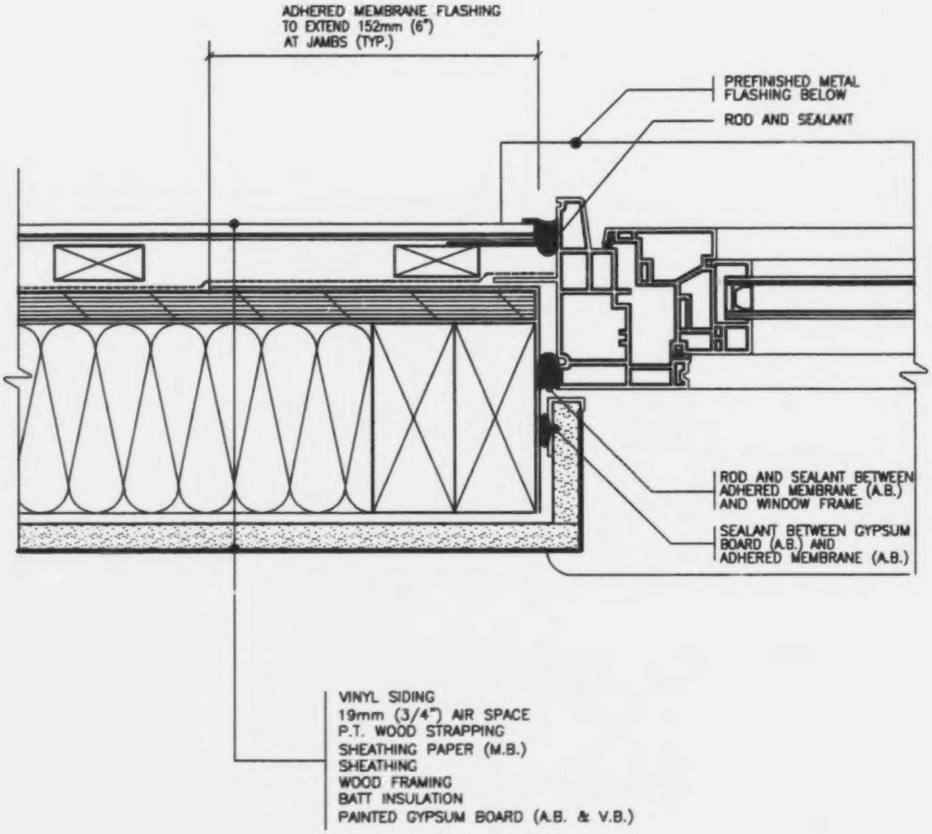
Use of Adhered Membrane
The use of excessive amounts of adhered membrane should be avoided particularly at locations that would tend to trap the vertical downward migration of any moisture present. The presence of adhered membrane and polyethylene creates a vapour impermeable pocket from which it is very difficult for any incidental moisture to dry. Therefore, while the use of adhered membrane is advisable at the window sills, and at least part way up the window jambs, its use at window heads should be avoided.


ADHERED MEMBRANE FLASHING TO EXTEND 150mm (6") AT JAMBS (TYP.)
25mm (1")
PREFINISHED METAL SILL FLASHING BELOW
SEALANT & BACKER ROD
HEAD FLASHING ABOVE
ROD AND SEALANT JOINT AT WINDOW FRAME TO ADHERED MEMBRANE (A.B. AND V.B.)
LAP AND SEAL POLYETHYLENE (A.B. & V.B.) TO ADHERED MEMBRANE (A.B. AND V.B.)
WOOD SIDING
19mm (3/4") AIR SPACE
P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. AND V.B.)
GYPSUM BOARD

WINDOW JAMB 12SPA

SEALED POLYETHYLENE APPROACH

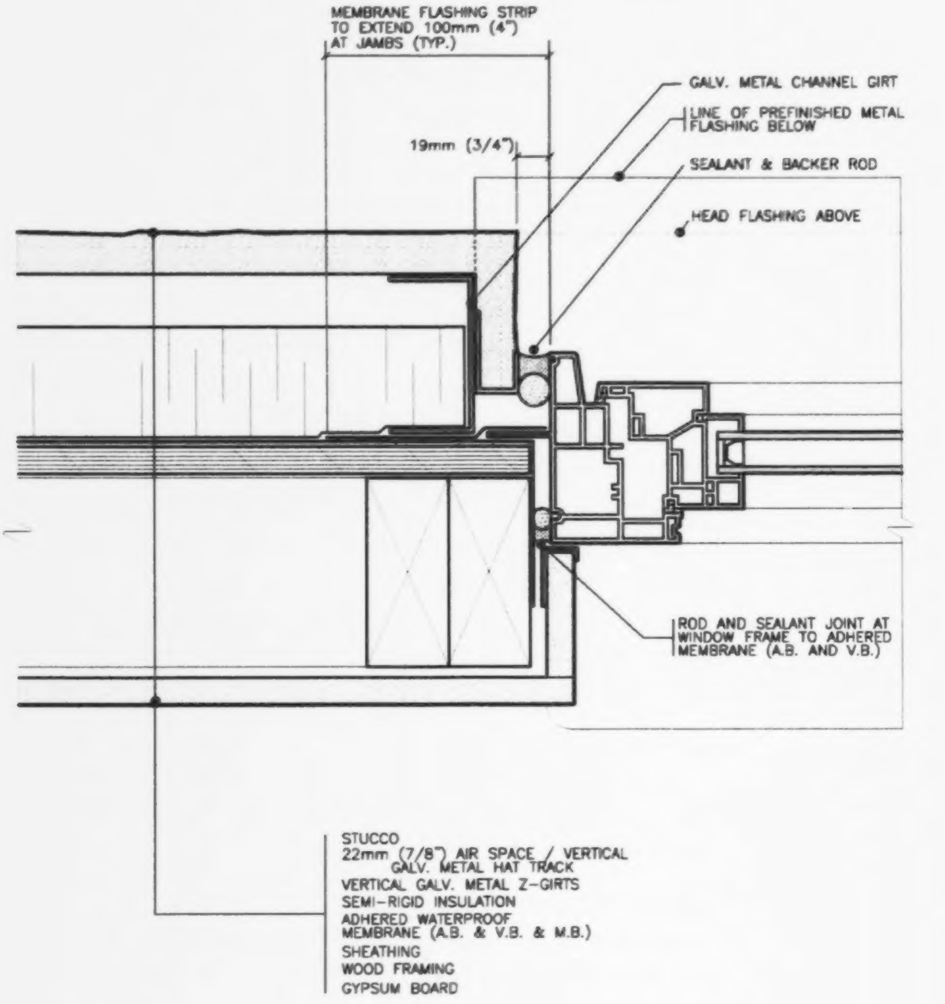
Detail 12 SPA: ***Window Jamb–Sealed Polyethylene Approach***


ADHERED MEMBRANE FLASHING TO EXTEND 152mm (6") AT JAMBS (TYP.)
PREFINISHED METAL FLASHING BELOW
ROD AND SEALANT
ROD AND SEALANT BETWEEN ADHERED MEMBRANE (A.B.) AND WINDOW FRAME
SEALANT BETWEEN GYPSUM BOARD (A.B.) AND ADHERED MEMBRANE (A.B.)
VINYL SIDING
19mm (3/4") AIR SPACE
P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
PAINTED GYPSUM BOARD (A.B. & V.B.)

WINDOW JAMB 12ADA

AIRTIGHT DRYWALL APPROACH

Detail 12 ADA: Window Jamb–Airtight Drywall Approach


MEMBRANE FLASHING STRIP
TO EXTEND 100mm (4")
AT JAMBS (TYP.)
GALV. METAL CHANNEL GIRT
LINE OF PREFINISHED METAL
FLASHING BELOW
19mm (3/4")
SEALANT & BACKER ROD
HEAD FLASHING ABOVE
ROD AND SEALANT JOINT AT
WINDOW FRAME TO ADHERED
MEMBRANE (A.B. AND V.B.)
STUCCO
22mm (7/8") AIR SPACE / VERTICAL
GALV. METAL HAT TRACK
VERTICAL GALV. METAL Z-GIRTS
SEMI-RIGID INSULATION
ADHERED WATERPROOF
MEMBRANE (A.B. & V.B. & M.B.)
SHEATHING
WOOD FRAMING
GYPSUM BOARD

WINDOW JAMB

12EABA

EXTERIOR AIR BARRIER APPROACH

Detail 12 EABA: Window Jamb–Exterior Air Barrier Approach

DETAIL 13–WINDOW SILL

Drainage

The sill detail has been developed to accommodate minor water leakage which may occur through the window frame. Water that penetrates the window will drain onto the adhered membrane flashing and will subsequently drain off of the sloped membrane flashing into the cavity. To achieve drainage, a path must be created between the window sill flange and the membrane, or the flange must be notched to allow drainage. If adequate drainage is not obtained at the window sill, water accumulation will increase the significance of any anomalies in the membrane flashing.

It is also possible to drain water from the sub-sill area directly to the exterior with a metal sub-sill flashing. Care must be taken in utilizing this approach; to minimize thermal bridging, and to not introduce a moisture ingress point at the sub-sill.

Sill Drip Flashing

Sill drip flashings are recommended to direct water that runs down the face of the window away from the wall surface below.

Sill flashings also reduce the problem of staining of the wall directly below the weep holes in the window.

Some window assemblies use weep holes that drain from the bottom of the window frame. The sill details must accommodate these various locations for the weep holes.

Air Barrier

Air barrier continuity is maintained by sealing the joint between the window frame and the self-adhered membrane flashing. The membrane is in turn sealed to the polyethylene.

Airtight Drywall Approach

Continuity of the air barrier is achieved by sealing the gypsum board to the self-adhered membrane, which in turn is sealed to the window frame.

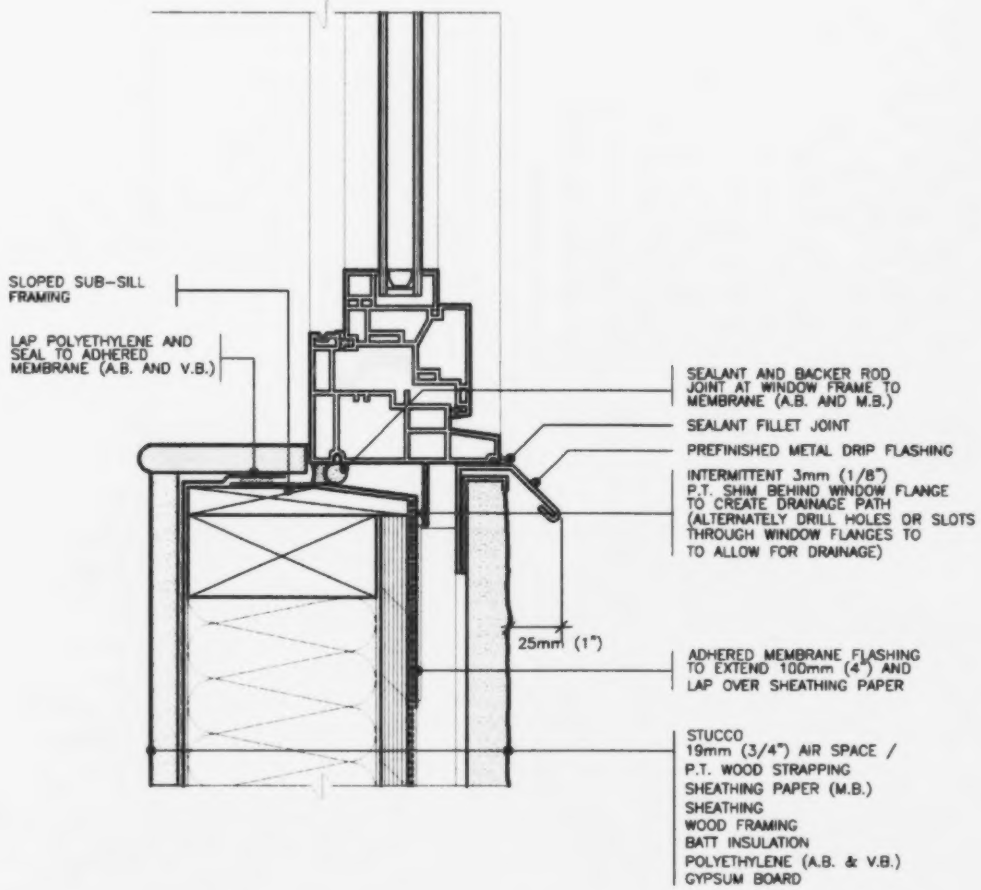
Exterior Air Barrier Approach

Air barrier continuity is maintained by sealing the joint between the window frame and the adhered waterproof membrane, which returns into the rough opening.

The complete installation of a head-jamb detail, and a sill-jamb detail are illustrated of pages 6-88 and 6-89 respectively.

Renewals

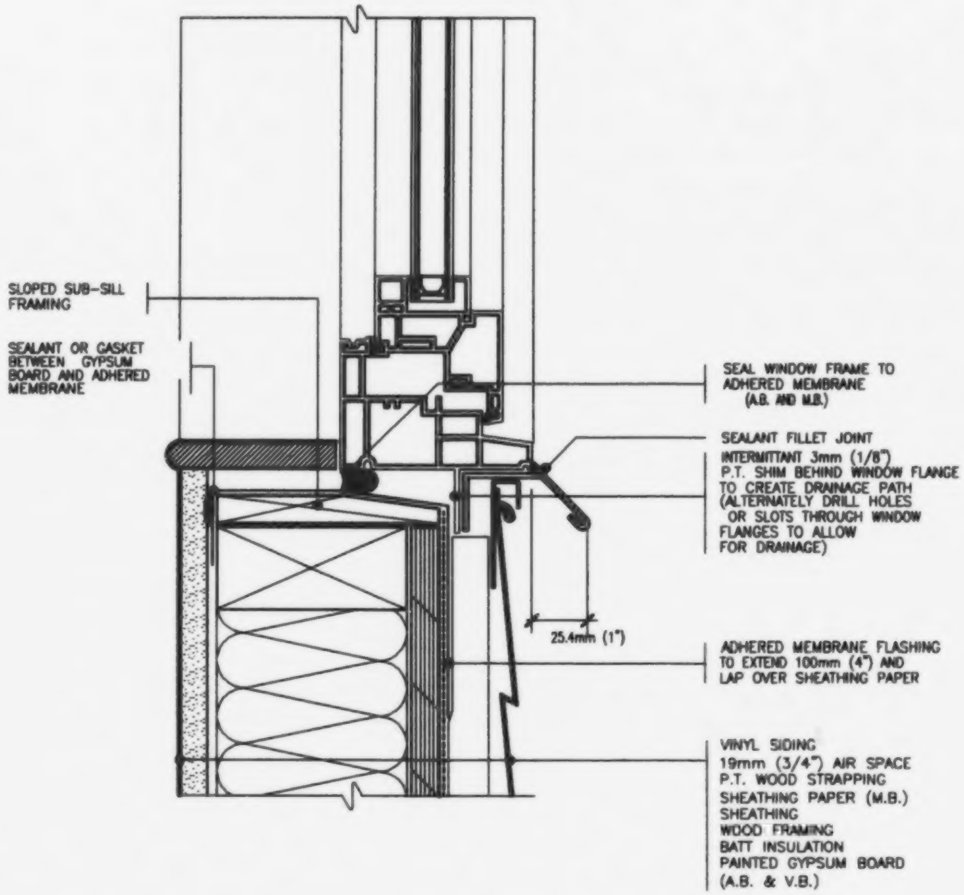
When using flange type windows consideration should be given to the need for replacement of the windows prior to requiring cladding replacement. Cost effective renewals could be facilitated through the use of a removable perimeter band detail. Alternately, rebate or box type window frame sections can generally be replaced with minimal disruption to the cladding.


SLOPED SUB-SILL FRAMING
LAP POLYETHYLENE AND SEAL TO ADHERED MEMBRANE (A.B. AND V.B.)
SEALANT AND BACKER ROD JOINT AT WINDOW FRAME TO MEMBRANE (A.B. AND M.B.)
SEALANT FILLET JOINT
PREFINISHED METAL DRIP FLASHING
INTERMITTENT 3mm (1/8") P.T. SHIM BEHIND WINDOW FLANGE TO CREATE DRAINAGE PATH (ALTERNATELY DRILL HOLES OR SLOTS THROUGH WINDOW FLANGES TO TO ALLOW FOR DRAINAGE)
25mm (1")
ADHERED MEMBRANE FLASHING TO EXTEND 100mm (4") AND LAP OVER SHEATHING PAPER
STUCCO
19mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD

WINDOW SILL 13SPA

SEALED POLYETHYLENE APPROACH

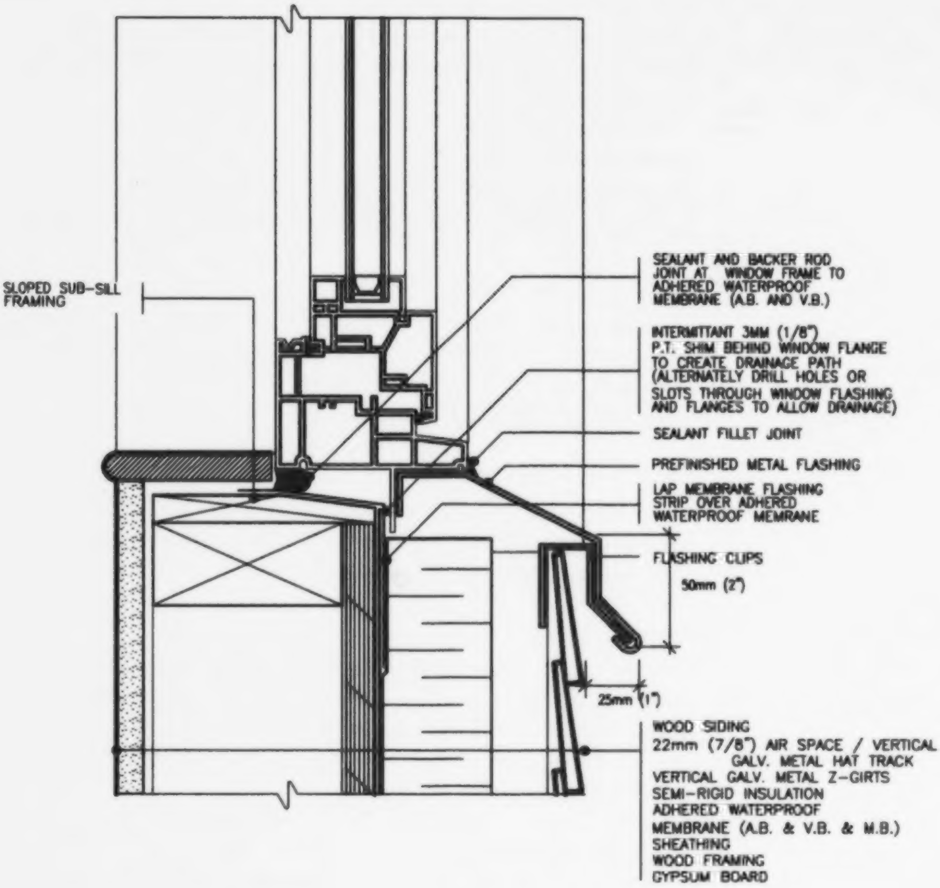
Detail 13 SPA: Window Sill–Sealed Polethylene Approach


SLOPED SUB-SILL FRAMING
SEALANT OR GASKET BETWEEN GYPSUM BOARD AND ADHERED MEMBRANE
SEAL WINDOW FRAME TO ADHERED MEMBRANE (A.B. AND M.B.)
SEALANT FILLET JOINT
INTERMITTANT 3mm (1/8") P.T. SHIM BEHIND WINDOW FLANGE TO CREATE DRAINAGE PATH (ALTERNATELY DRILL HOLES OR SLOTS THROUGH WINDOW FLANGES TO ALLOW FOR DRAINAGE)
25.4mm (1")
ADHERED MEMBRANE FLASHING TO EXTEND 100mm (4") AND LAP OVER SHEATHING PAPER
VINYL SIDING
19mm (3/4") AIR SPACE
P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
PAINTED GYPSUM BOARD (A.B. & V.B.)

WINDOW SILL 13ADA

AIRTIGHT DRYWALL APPROACH

Detail 13 ADA: Window Sill–Airtight Drywall Approach


SLOPED SUB-SILL FRAMING
SEALANT AND BACKER ROD JOINT AT WINDOW FRAME TO ADHERED WATERPROOF MEMBRANE (A.B. AND V.B.)
INTERMITTANT 3MM (1/8") P.T. SHIM BEHIND WINDOW FLANGE TO CREATE DRAINAGE PATH (ALTERNATELY DRILL HOLES OR SLOTS THROUGH WINDOW FLASHING AND FLANGES TO ALLOW DRAINAGE)
SEALANT FILLET JOINT
PREFINISHED METAL FLASHING
LAP MEMBRANE FLASHING STRIP OVER ADHERED WATERPROOF MEMRANE
FLASHING CLIPS
50mm (2")
25mm (1")
WOOD SIDING
22mm (7/8") AIR SPACE / VERTICAL GALV. METAL HAT TRACK
VERTICAL GALV. METAL Z-GIRTS
SEMI-RIGID INSULATION
ADHERED WATERPROOF MEMBRANE (A.B. & V.B. & M.B.)
SHEATHING
WOOD FRAMING
GYPSUM BOARD

WINDOW SILL 13EABA

EXTERIOR AIR BARRIER APPROACH

Detail 13 EABA: Window Sill–Exterior Air Barrier Approach

DETAIL 14–DOOR SILL–PROTECTED MEMBRANE PEDESTRIAN SURFACE

Sill Height

Whenever possible, door sills should be elevated above the drainage surface. The higher the door sill above the drainage surface, the less the potential for water ingress as a result of snow melt or the back-up of water on the drainage surface. (See also notes concerning accessible door sills for Details 16 and 17).

Metal Flashing

The pre-finished metal flashing should be kept a minimum of 12 mm above the membrane surface to reduce the potential for corrosion of the flashing.

Membrane Flashing

The adhered membrane flashing under the door threshold should connect with a similar membrane wrapping the rough opening at the jambs. The method of providing air barrier continuity at the door jamb is similar to that described for Detail 12 (page 6-44).

Deck Membrane

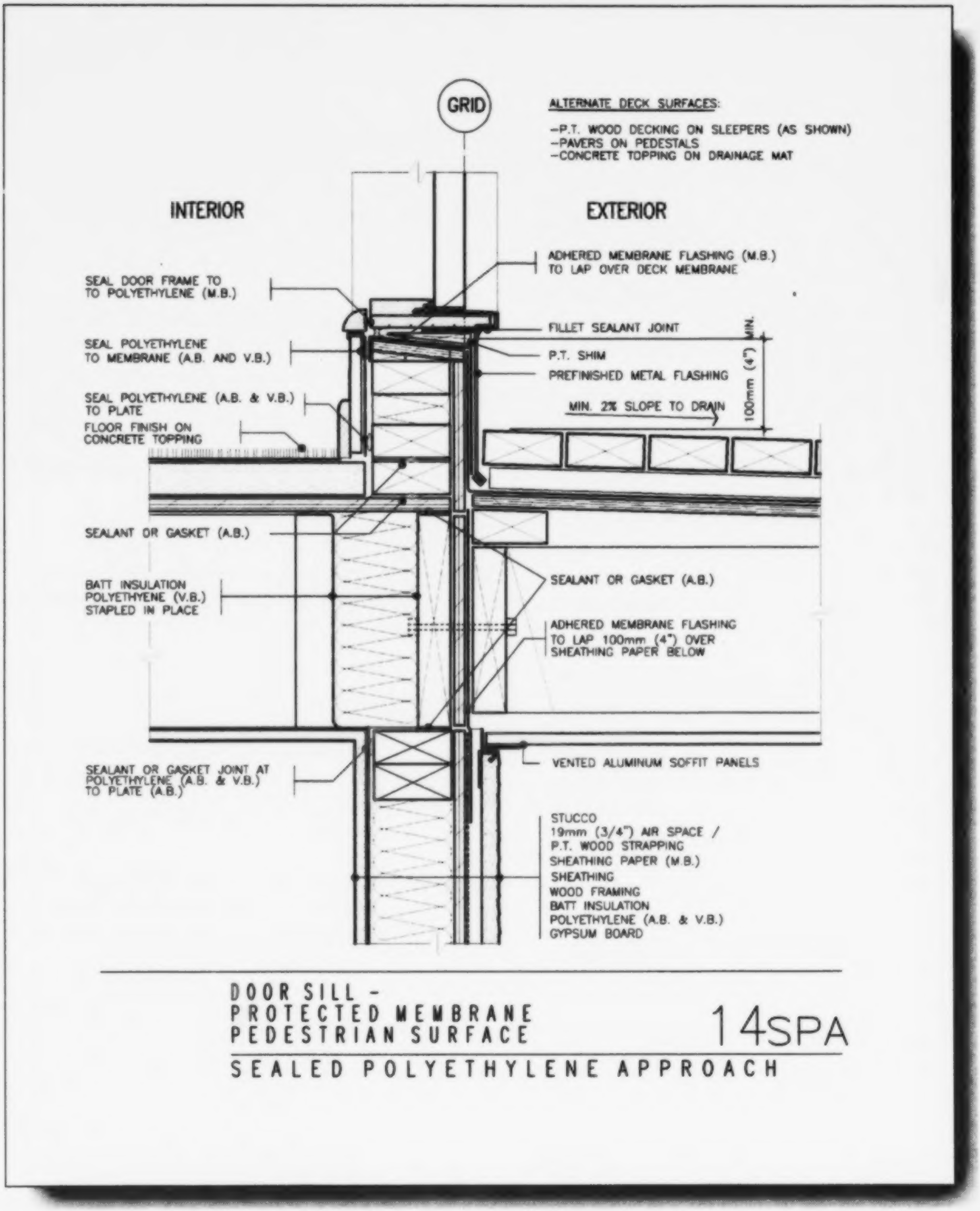
Application requirements and details for deck membranes vary. Manufacturers should be contacted to confirm specific product requirements for membrane reinforcing, or cants at corners.

Slope to Drain

Care should be taken when designing slopes to drain for decks and walkways that are partially supported by framing members in heated walls and members in non-heated walls, because members in heated walls will shrink more than members in unheated walls. Over time this differential shrinkage may reduce or reverse the original slope.

Alternative Detail

As a second approach, the vapour barrier, gaskets at the rim joist, and insulation could be replaced with spray-in-place foam insulation. The use of spray-in-place foam is indicated as an alternative approach for Detail 4 (page 6-14).


GRID
ALTERNATE DECK SURFACES:
-P.T. WOOD DECKING ON SLEEPERS (AS SHOWN)
-PAVERS ON PEDESTALS
-CONCRETE TOPPING ON DRAINAGE MAT
INTERIOR
EXTERIOR
ADHERED MEMBRANE FLASHING (M.B.) TO LAP OVER DECK MEMBRANE
SEAL DOOR FRAME TO TO POLYETHYLENE (M.B.)
FILLET SEALANT JOINT
SEAL POLYETHYLENE TO MEMBRANE (A.B. AND V.B.)
P.T. SHIM
PREFINISHED METAL FLASHING
100mm (4") MIN.
SEAL POLYETHYLENE (A.B. & V.B.) TO PLATE
MIN. 2% SLOPE TO DRAIN
FLOOR FINISH ON CONCRETE TOPPING
SEALANT OR GASKET (A.B.)
SEALANT OR GASKET (A.B.)
BATT INSULATION
POLYETHYENE (V.B.)
STAPLED IN PLACE
ADHERED MEMBRANE FLASHING TO LAP 100mm (4") OVER SHEATHING PAPER BELOW
VENTED ALUMINUM SOFFIT PANELS
SEALANT OR GASKET JOINT AT POLYETHYLENE (A.B. & V.B.) TO PLATE (A.B.)
STUCCO
19mm (3/4") AIR SPACE /
P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD
DOOR SILL -
PROTECTED MEMBRANE
PEDESTRIAN SURFACE
14SPA
SEALED POLYETHYLENE APPROACH

***Detail 14 SPA:* Door Sill–Protected Membrane Pedestrian Surface–Sealed Polyethylene Approach**

DETAIL 15–DOOR SILL–EXPOSED MEMBRANE PEDESTRIAN SURFACE

Sill Height

Whenever possible, door sills should be elevated above the drainage surface. The higher the door sill above the drainage surface, the less the potential for water ingress as a result of snow melt or the back-up of water on the drainage surface. (See also notes concerning accessible door sills for Details 16 and 17).

Metal Flashing

The pre-finished metal flashing should be kept a minimum of 12 mm above the membrane surface to reduce the potential for corrosion of the flashing.

Membrane Flashing

The adhered membrane flashing under the door threshold should connect with a similar membrane wrapping the rough opening at the jambs. The method of providing air barrier continuity at the door jamb is similar to that shown on Detail 12 (page 6-44).

Deck Membrane

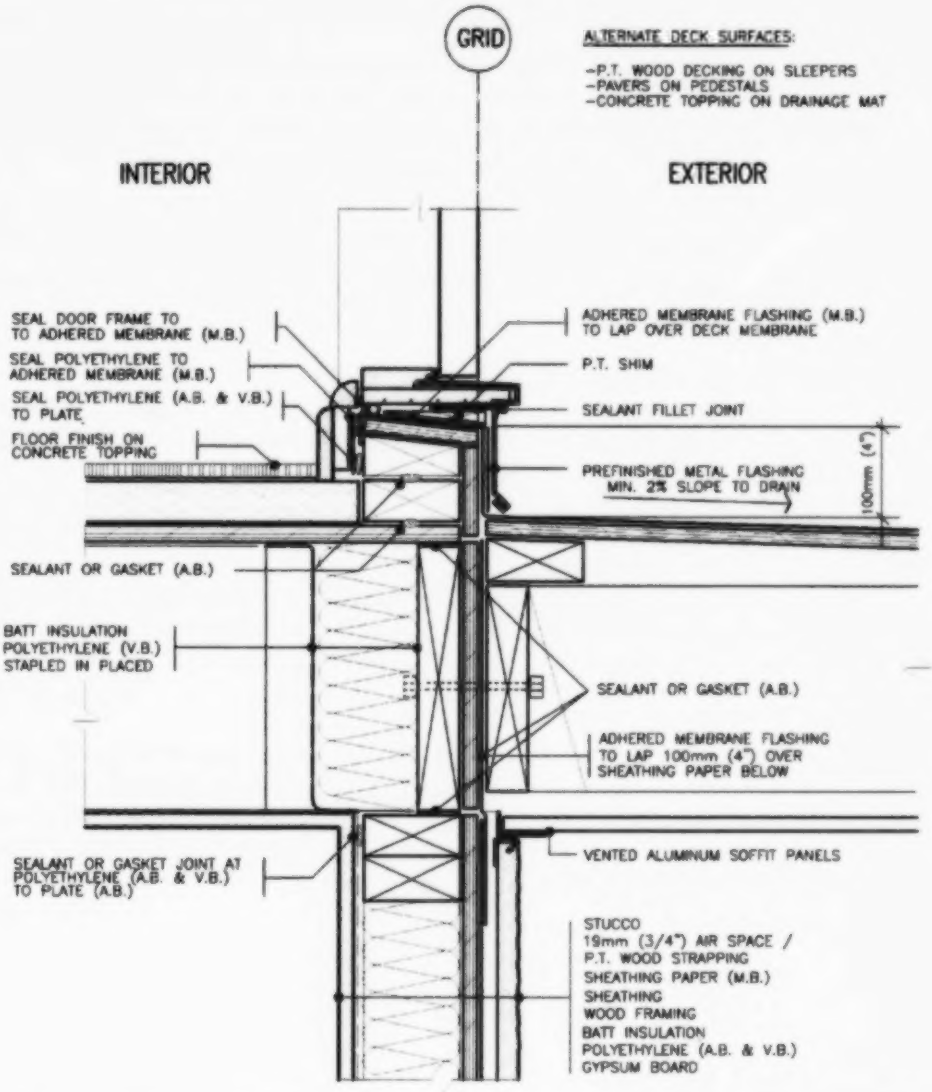
Application requirements and details for deck membranes vary. Manufacturers should be contacted to confirm specific product requirements for membrane reinforcing, or cants at corners.

Slope to Drain

Care should be taken when designing slopes to drain for decks and walkways that are partially supported by framing members in heated walls and members in non-heated walls, because members in heated walls will shrink more than members in unheated walls. Over time this differential shrinkage may reduce or reverse the original slope.

Alternative Detail

As a second approach, the vapour barrier, gaskets at the rim joist, and insulation could be replaced with spray-in-place foam insulation. The use of spray-in-place foam is indicated as an alternative approach for Detail 4 (page 6-14).


GRID
ALTERNATE DECK SURFACES:
-P.T. WOOD DECKING ON SLEEPERS
-PAVERS ON PEDESTALS
-CONCRETE TOPPING ON DRAINAGE MAT
INTERIOR
EXTERIOR
SEAL DOOR FRAME TO TO ADHERED MEMBRANE (M.B.)
SEAL POLYETHYLENE TO ADHERED MEMBRANE (M.B.)
SEAL POLYETHYLENE (A.B. & V.B.) TO PLATE
FLOOR FINISH ON CONCRETE TOPPING
ADHERED MEMBRANE FLASHING (M.B.) TO LAP OVER DECK MEMBRANE
P.T. SHIM
SEALANT FILLET JOINT
PREFINISHED METAL FLASHING MIN. 2% SLOPE TO DRAIN
100mm (4")
SEALANT OR GASKET (A.B.)
BATT INSULATION
POLYETHYLENE (V.B.)
STAPLED IN PLACED
SEALANT OR GASKET (A.B.)
ADHERED MEMBRANE FLASHING TO LAP 100mm (4") OVER SHEATHING PAPER BELOW
VENTED ALUMINUM SOFFIT PANELS
SEALANT OR GASKET JOINT AT POLYETHYLENE (A.B. & V.B.) TO PLATE (A.B.)
STUCCO
19mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD

DOOR SILL –
EXPOSED MEMBRANE
PEDESTRIAN SURFACE
15SPA
SEALED POLYETHYLENE APPROACH

Detail 15 SPA: *Door Sill–Exposed Membrane Pedestrian Surface–Sealed Polyethylene Approach*

DETAIL 16–ACCESSIBLE DOOR SILL–PROTECTED MEMBRANE PEDESTRIAN SURFACE

This door sill configuration should only be used in locations where the door is located in a low exposure condition and there is low probability of snow accumulation on the deck. The vertical distance between the deck membrane and the door threshold can be increased if larger sleepers are used below the wood deck boards.

Metal Flashing

The pre-finished metal flashing should be kept a minimum of 12 mm above the membrane surface to reduce the potential for corrosion of the flashing.

Membrane Flashing

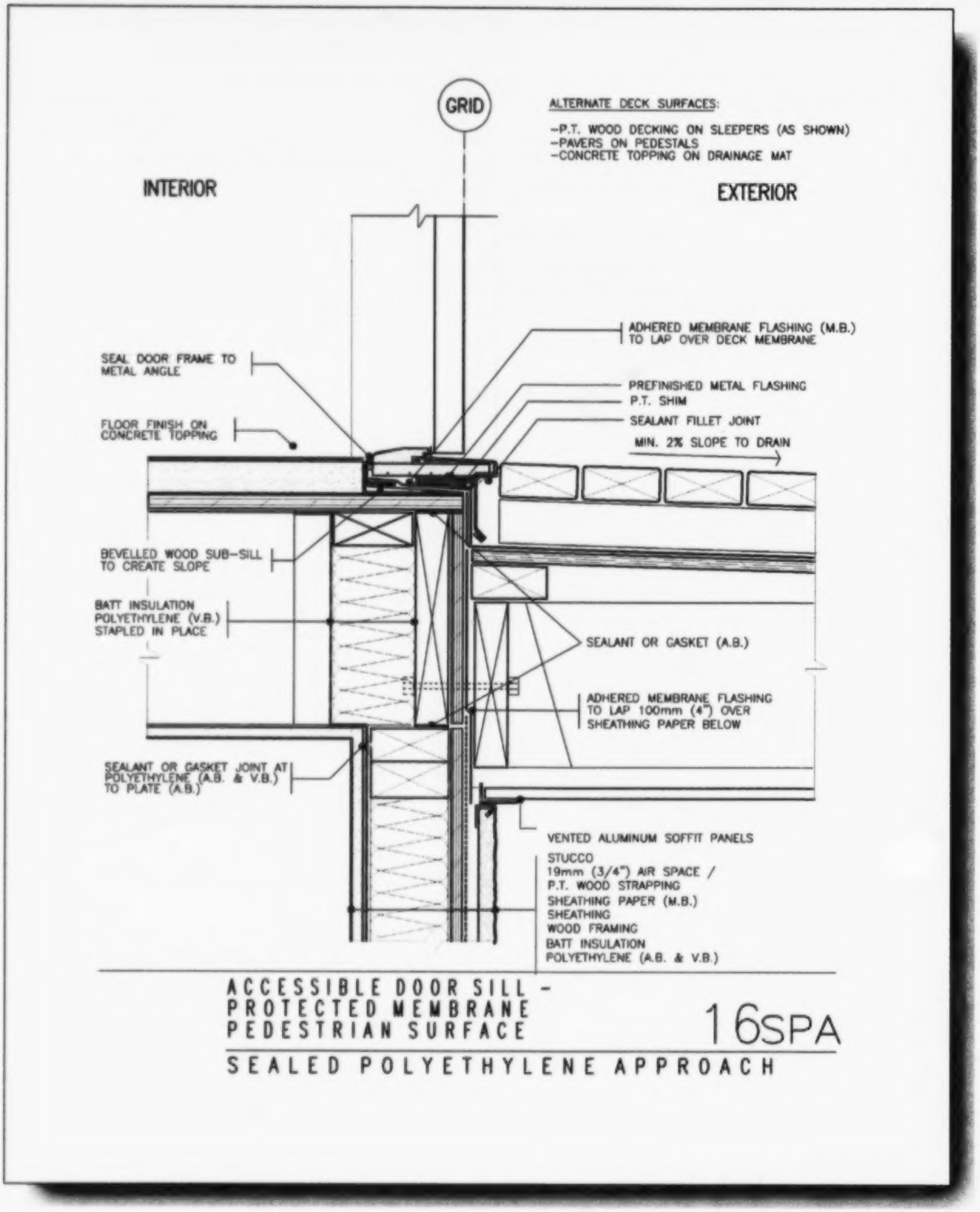
The adhered membrane flashing under the door threshold should connect with a similar membrane wrapping the rough opening at the jambs. The method of providing air barrier continuity at the door jamb is similar to that shown on Detail 12 (see page 6-44).

Deck Membrane

Application requirements and details for deck membranes vary. Manufacturers should be contacted to confirm specific product requirements for membrane reinforcing, or cants at corners.

Slope to Drain

Care should be taken when designing slopes to drain for decks and walkways that are partially supported by framing members in heated walls and members in non-heated walls, because members in heated walls will shrink more than members in unheated walls. Over time this differential shrinkage may reduce or reverse the original slope.


GRID
ALTERNATE DECK SURFACES:
-P.T. WOOD DECKING ON SLEEPERS (AS SHOWN)
-PAVERS ON PEDESTALS
-CONCRETE TOPPING ON DRAINAGE MAT
INTERIOR
EXTERIOR
ADHERED MEMBRANE FLASHING (M.B.) TO LAP OVER DECK MEMBRANE
SEAL DOOR FRAME TO METAL ANGLE
PREFINISHED METAL FLASHING
P.T. SHIM
SEALANT FILLET JOINT
FLOOR FINISH ON CONCRETE TOPPING
MIN. 2% SLOPE TO DRAIN
BEVELLED WOOD SUB-SILL TO CREATE SLOPE
BATT INSULATION POLYETHYLENE (V.B.) STAPLED IN PLACE
SEALANT OR GASKET (A.B.)
ADHERED MEMBRANE FLASHING TO LAP 100mm (4") OVER SHEATHING PAPER BELOW
SEALANT OR GASKET JOINT AT POLYETHYLENE (A.B. & V.B.) TO PLATE (A.B.)
VENTED ALUMINUM SOFFIT PANELS
STUCCO
19mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
ACCESSIBLE DOOR SILL - PROTECTED MEMBRANE PEDESTRIAN SURFACE
16SPA
SEALED POLYETHYLENE APPROACH

***Detail 16 SPA:** Accessible Door Sill–Protected Membrane Pedestrian Surface–Sealed Polyethylene Approach*

DETAIL 17–ACCESSIBLE DOOR SILL–EXPOSED MEMBRANE PEDESTRIAN SURFACE

This door sill configuration should only be used in locations where the door is located in a low exposure condition and there is limited probability of snow accumulation on the deck.

Membrane Flashing

The adhered membrane flashing under the door threshold should connect with a similar membrane wrapping the rough opening at the jambs. The method of providing air barrier continuity at the door jamb is similar to that shown on Detail 12 (page 6-44).

Deck Membrane

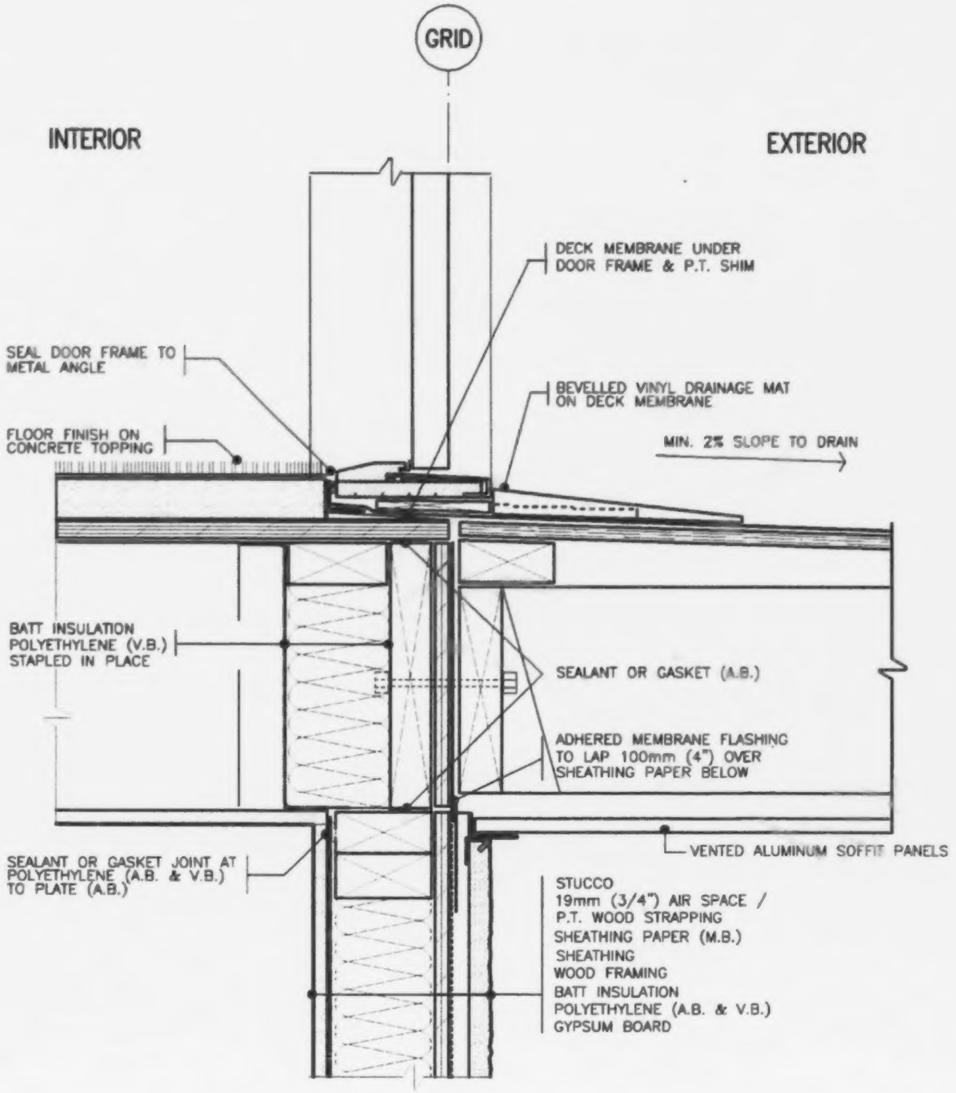
Application requirements and details for deck membranes vary. Manufacturers should be contacted to confirm specific product requirements for membrane reinforcing, or cants at corners.

Slope to Drain

Care should be taken when designing slopes to drain for decks and walkways that are partially supported by framing members in heated walls and members in non-heated walls, because members in heated walls will shrink more than members in unheated walls. Over time this differential shrinkage may reduce or reverse the original slope.

Alternative Detail

As a second approach, the vapour barrier, gaskets at the rim joist, and insulation could be replaced with spray-in-place foam insulation. The use of spray-in-place foam is indicated as an alternative approach in Detail 4 (page 6-14).


GRID
INTERIOR
EXTERIOR
DECK MEMBRANE UNDER DOOR FRAME & P.T. SHIM
SEAL DOOR FRAME TO METAL ANGLE
BEVELLED VINYL DRAINAGE MAT ON DECK MEMBRANE
FLOOR FINISH ON CONCRETE TOPPING
MIN. 2% SLOPE TO DRAIN
BATT INSULATION
POLYETHYLENE (V.B.) STAPLED IN PLACE
SEALANT OR GASKET (A.B.)
ADHERED MEMBRANE FLASHING TO LAP 100mm (4") OVER SHEATHING PAPER BELOW
VENTED ALUMINUM SOFFIT PANELS
SEALANT OR GASKET JOINT AT POLYETHYLENE (A.B. & V.B.) TO PLATE (A.B.)
STUCCO
19mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD

ACCESSIBLE DOOR SILL -
EXPOSED MEMBRANE
PEDESTRIAN SURFACE

17SPA

SEALED POLYETHYLENE APPROACH

***Detail 17 SPA:** Accessible Door Sill–Exposed Membrane Pedestrian Surface–Sealed Polyethylene Approach*

DETAIL 18–DOOR SILL–PEDESTRIAN SURFACE ROOF

Membrane Flashing

The adhered membrane flashing under the door threshold should connect with a similar membrane wrapping the rough opening at the jambs. The method of providing air barrier continuity at the door jamb is similar to that shown on Detail 12 (page 6-44).

Deck Membrane

Application requirements and details for deck membranes vary. Manufacturers should be contacted to confirm specific product requirements for membrane reinforcing, or cants at corners.

Air Barrier

There are two possible air barrier systems for this detail. The selected system will depend on the air barrier system used on the exterior wall below the roof level. These systems are described below:

- The roof membrane can be used as the air barrier provided it is properly tied into the air barrier in the wall below. This tie-in can be accomplished using spray-in-place foam at the rim joist or using gaskets to transfer the air barrier from the plywood deck to the top plate in the wall.
- The polyethylene in the ceiling can be used as the air barrier, provided the air barrier is transferred from the ceiling polyethylene up into the polyethylene in the curb below the door.

Location of Insulation

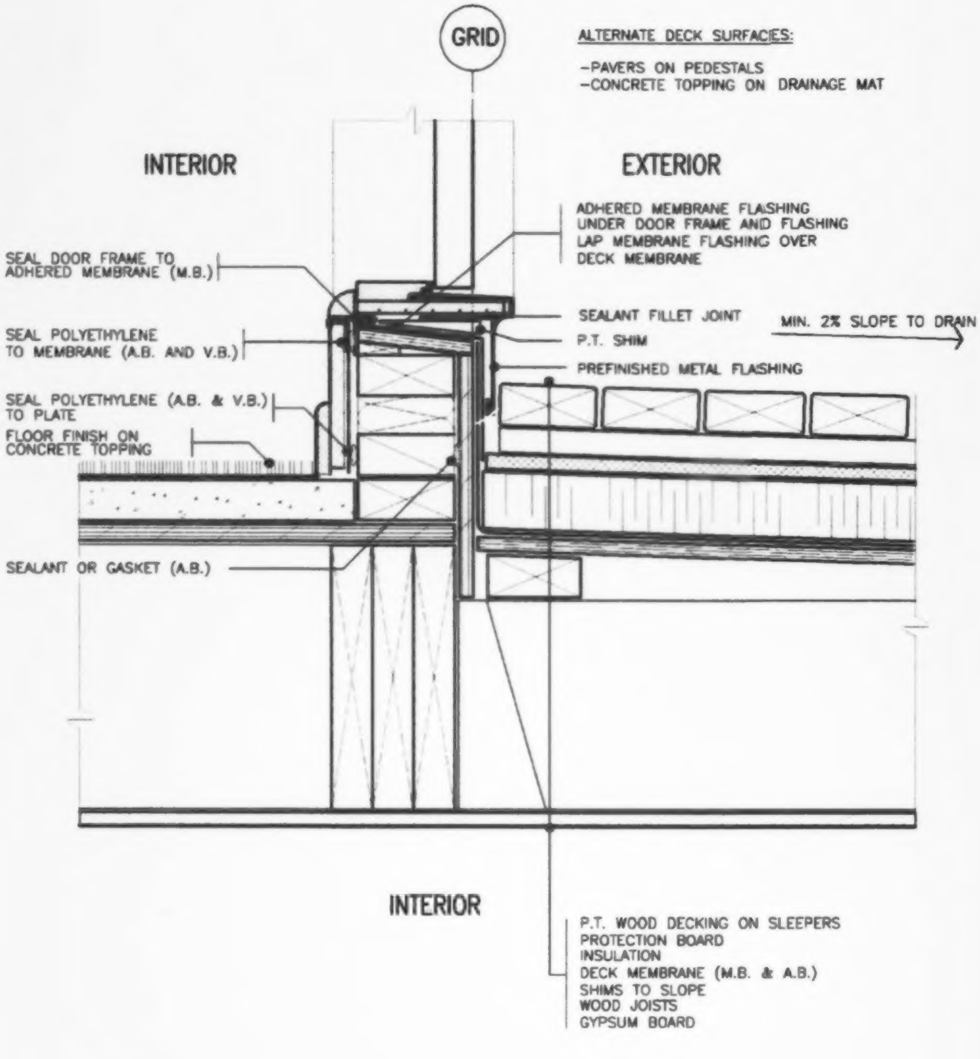
If this detail is constructed with the insulation between the roof joists rather than on top of the membrane, the space above the insulation must be vented. This is not a recommended approach as achieving uniformly distributed venting of the space over the insulation is difficult and often not effective.

Airtight Drywall Approach

Continuity of the air barrier is achieved by connecting the gypsum board on the interior face of the threshold through the floor framing, using sealant or gaskets to the ceiling gypsum board which in turn connects to the wall gypsum board below.

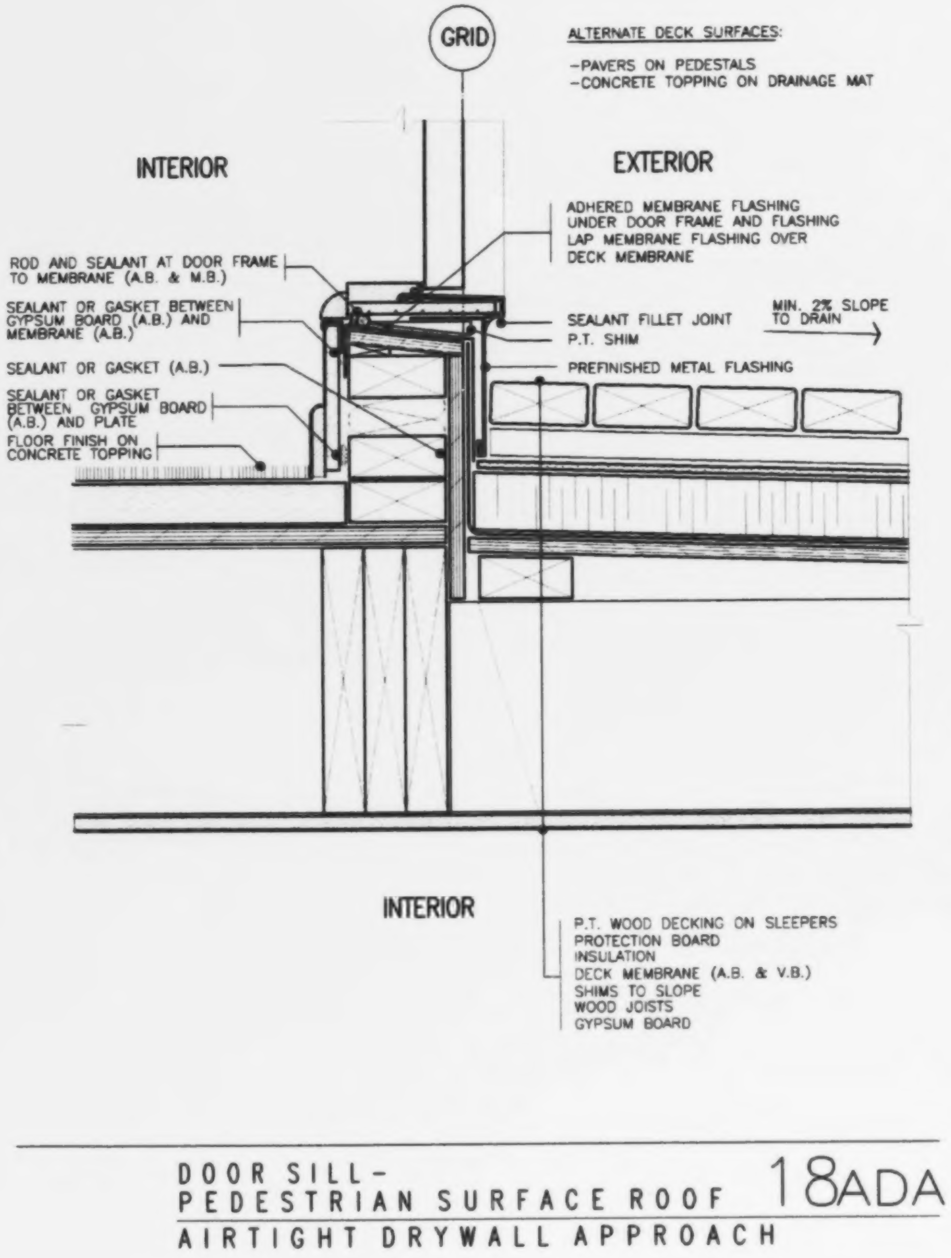
Exterior Air Barrier Approach

The roof membrane provides the air barrier continuity connecting the wall membrane or membrane flashing to the wall membrane below. As described above for the sealed polyethylene approach, the tie-in can be accomplished using spray-in-place foam at the rim joist or using gaskets to transfer the air barrier from the plywood deck to the top plate in the wall.

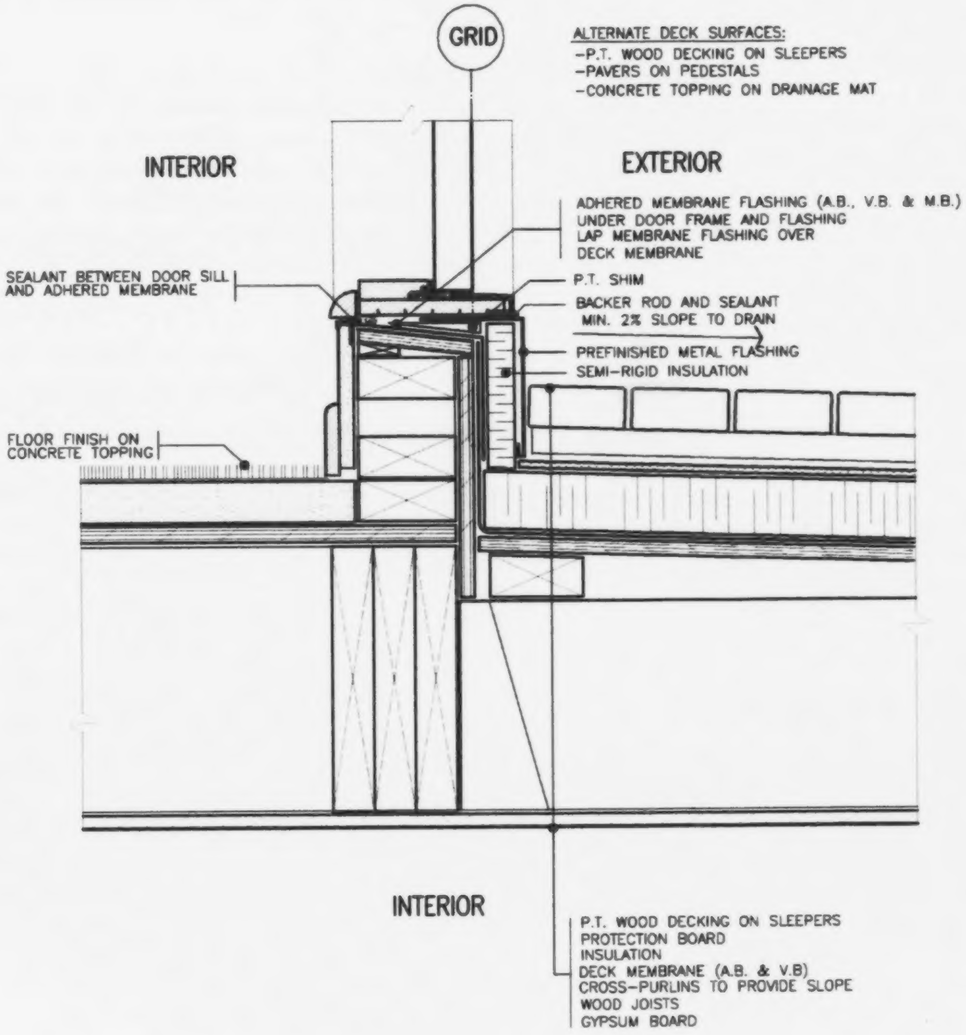

GRID
ALTERNATE DECK SURFACES:
-PAVERS ON PEDESTALS
-CONCRETE TOPPING ON DRAINAGE MAT
INTERIOR
EXTERIOR
ADHERED MEMBRANE FLASHING UNDER DOOR FRAME AND FLASHING LAP MEMBRANE FLASHING OVER DECK MEMBRANE
SEAL DOOR FRAME TO ADHERED MEMBRANE (M.B.)
SEALANT FILLET JOINT
MIN. 2% SLOPE TO DRAIN
SEAL POLYETHYLENE TO MEMBRANE (A.B. AND V.B.)
P.T. SHIM
PREFINISHED METAL FLASHING
SEAL POLYETHYLENE (A.B. & V.B.) TO PLATE
FLOOR FINISH ON CONCRETE TOPPING
SEALANT OR GASKET (A.B.)
INTERIOR
P.T. WOOD DECKING ON SLEEPERS
PROTECTION BOARD
INSULATION
DECK MEMBRANE (M.B. & A.B.)
SHIMS TO SLOPE
WOOD JOISTS
GYPSUM BOARD

DOOR SILL–
PEDESTRIAN SURFACE ROOF 18SPA
SEALED POLYETHYLENE APPROACH

Detail 18 SPA: *Door Sill–Pedestrian Surface Roof–Sealed Polyethylene Approach*


GRID
ALTERNATE DECK SURFACES:
-PAVERS ON PEDESTALS
-CONCRETE TOPPING ON DRAINAGE MAT
INTERIOR
EXTERIOR
ADHERED MEMBRANE FLASHING UNDER DOOR FRAME AND FLASHING LAP MEMBRANE FLASHING OVER DECK MEMBRANE
ROD AND SEALANT AT DOOR FRAME TO MEMBRANE (A.B. & M.B.)
SEALANT OR GASKET BETWEEN GYPSUM BOARD (A.B.) AND MEMBRANE (A.B.)
SEALANT OR GASKET (A.B.)
SEALANT OR GASKET BETWEEN GYPSUM BOARD (A.B.) AND PLATE
FLOOR FINISH ON CONCRETE TOPPING
SEALANT FILLET JOINT
P.T. SHIM
MIN. 2% SLOPE TO DRAIN
PREFINISHED METAL FLASHING
INTERIOR
P.T. WOOD DECKING ON SLEEPERS
PROTECTION BOARD
INSULATION
DECK MEMBRANE (A.B. & V.B.)
SHIMS TO SLOPE
WOOD JOISTS
GYPSUM BOARD
DOOR SILL-
PEDESTRIAN SURFACE ROOF
18ADA
AIRTIGHT DRYWALL APPROACH

Detail 18 ADA: *Door Sill–Pedestrian Surface Roof–Airtight Drywall Approach*


GRID
ALTERNATE DECK SURFACES:
-P.T. WOOD DECKING ON SLEEPERS
-PAVERS ON PEDESTALS
-CONCRETE TOPPING ON DRAINAGE MAT
INTERIOR
EXTERIOR
ADHERED MEMBRANE FLASHING (A.B., V.B. & M.B.)
UNDER DOOR FRAME AND FLASHING
LAP MEMBRANE FLASHING OVER
DECK MEMBRANE
SEALANT BETWEEN DOOR SILL
AND ADHERED MEMBRANE
P.T. SHIM
BACKER ROD AND SEALANT
MIN. 2% SLOPE TO DRAIN
PREFINISHED METAL FLASHING
SEMI-RIGID INSULATION
FLOOR FINISH ON
CONCRETE TOPPING
INTERIOR
P.T. WOOD DECKING ON SLEEPERS
PROTECTION BOARD
INSULATION
DECK MEMBRANE (A.B. & V.B)
CROSS-PURLINS TO PROVIDE SLOPE
WOOD JOISTS
GYPSUM BOARD

DOOR SILL-
PEDESTRIAN SURFACE ROOF 18EABA
EXTERIOR AIR BARRIER APPROACH

***Detail 18 EABA:** Door Sill–Pedestrian Surface Roof–Exterior Air Barrier Approach*

DETAIL 19–WALL–PEDESTRIAN SURFACE

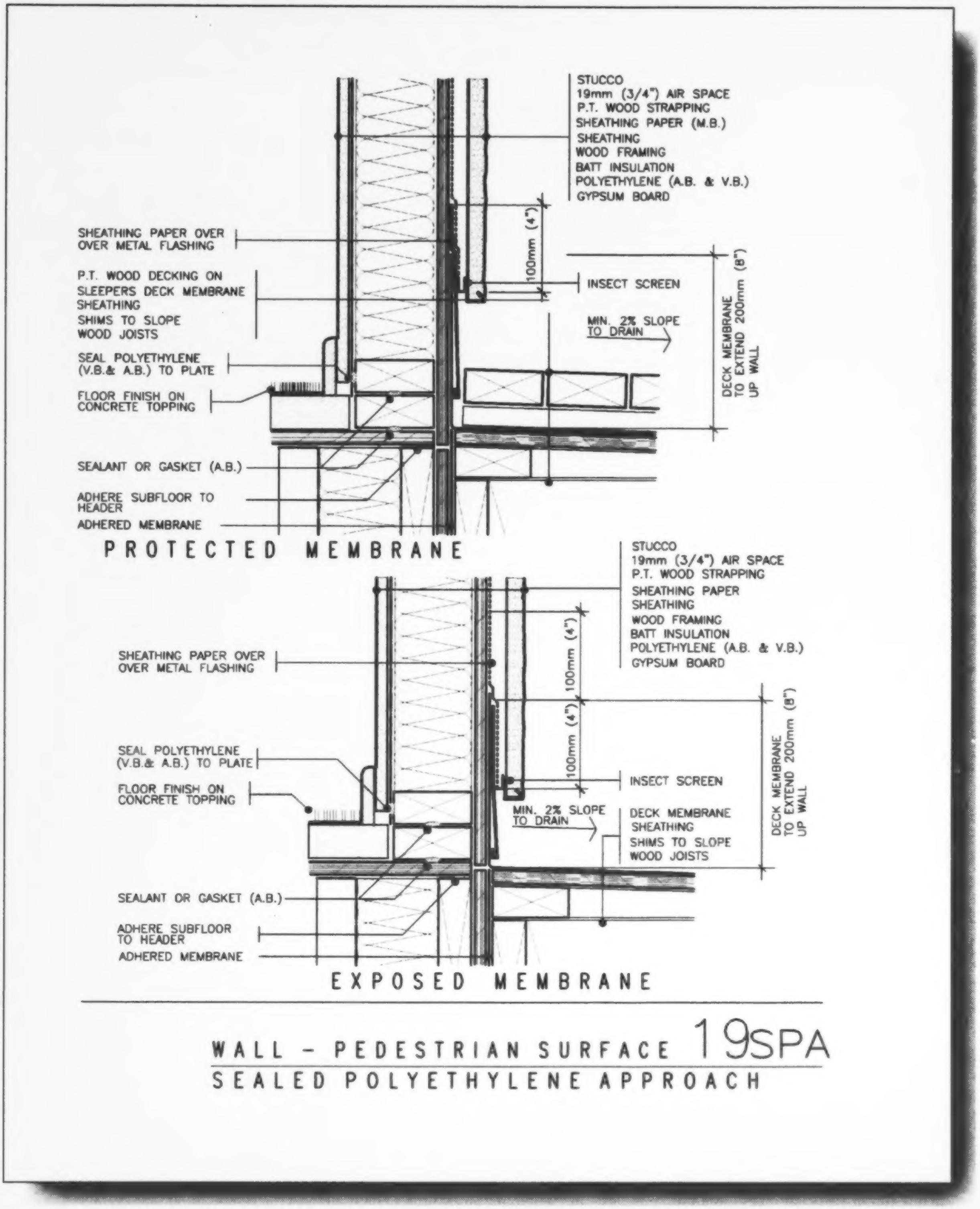
Deck Membrane

Application requirements and details for deck membranes vary. Manufacturers should be contacted to confirm specific product requirements for membrane reinforcing, or cants at corners. With some systems the metal flashing may not be required. If the stucco cladding is to be applied before the deck membrane is laid, a membrane starter strip applied to the vertical surface should be applied first. The main deck membrane can later be sealed to the starter strip and the joint protected by a metal flashing.

Membrane Protection

It is good practice to use a metal flashing to protect the waterproof membrane that turns up the wall to limit mechanical damage of the membrane.

If the selected deck membrane has an expected performance life less than that of the wall assembly, a two-piece flashing should be utilized. A two-piece flashing will allow replacement of the membrane system without removal of the cladding system.


STUCCO
19mm (3/4") AIR SPACE
P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD
SHEATHING PAPER OVER OVER METAL FLASHING
P.T. WOOD DECKING ON SLEEPERS DECK MEMBRANE
SHEATHING
SHIMS TO SLOPE
WOOD JOISTS
SEAL POLYETHYLENE (V.B.& A.B.) TO PLATE
FLOOR FINISH ON CONCRETE TOPPING
SEALANT OR GASKET (A.B.)
ADHERE SUBFLOOR TO HEADER
ADHERED MEMBRANE
100mm (4")
INSECT SCREEN
MIN. 2% SLOPE TO DRAIN
DECK MEMBRANE TO EXTEND 200mm (8") UP WALL
PROTECTED MEMBRANE
STUCCO
19mm (3/4") AIR SPACE
P.T. WOOD STRAPPING
SHEATHING PAPER
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. & V.B.)
GYPSUM BOARD
SHEATHING PAPER OVER OVER METAL FLASHING
100mm (4")
100mm (4")
SEAL POLYETHYLENE (V.B.& A.B.) TO PLATE
FLOOR FINISH ON CONCRETE TOPPING
INSECT SCREEN
MIN. 2% SLOPE TO DRAIN
DECK MEMBRANE
SHEATHING
SHIMS TO SLOPE
WOOD JOISTS
DECK MEMBRANE TO EXTEND 200mm (8") UP WALL
SEALANT OR GASKET (A.B.)
ADHERE SUBFLOOR TO HEADER
ADHERED MEMBRANE
EXPOSED MEMBRANE
WALL - PEDESTRIAN SURFACE 19SPA
SEALED POLYETHYLENE APPROACH

Detail 19 SPA: *Wall–Pedestrian Surface–Sealed Polyethylene Approach*

DETAIL 20–EXTERIOR EDGES–PEDESTRIAN SURFACE

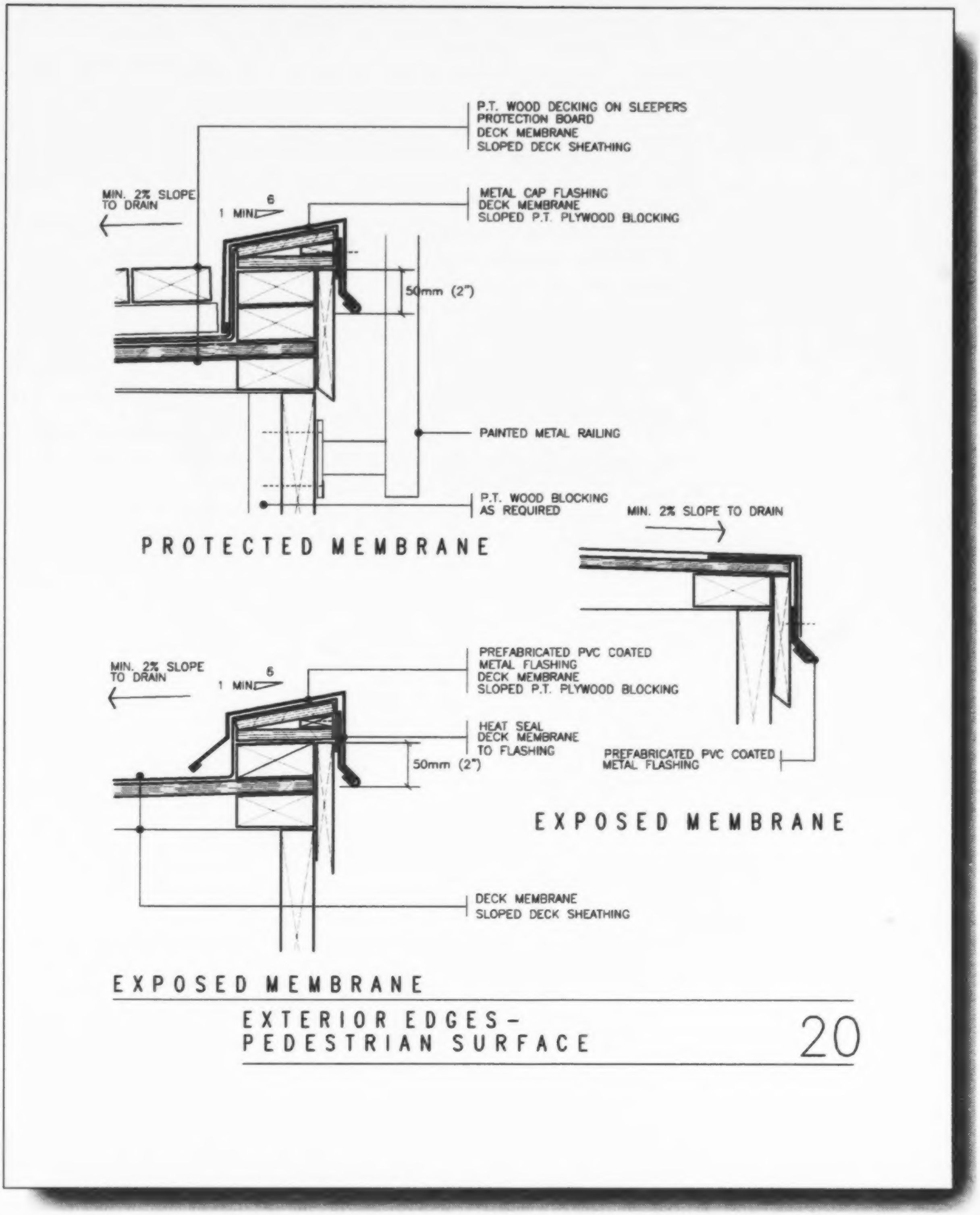
Deck Membrane

Where curbs are provided, the deck membrane is carried over the top of the curb and down the vertical face on the exterior of the curb.

Application requirements and details for deck membranes vary. Manufacturers should be contacted to confirm specific product requirements for membrane reinforcing, or cants at corners.

Guard Rails

Guard rails should always be attached to the vertical face balcony fascia, a wall surface or be supported in a manner that does not require fastening through the horizontal deck surface.


P.T. WOOD DECKING ON SLEEPERS
PROTECTION BOARD
DECK MEMBRANE
SLOPED DECK SHEATHING
MIN. 2% SLOPE TO DRAIN
1 MIN
6
METAL CAP FLASHING
DECK MEMBRANE
SLOPED P.T. PLYWOOD BLOCKING
50mm (2")
PAINTED METAL RAILING
P.T. WOOD BLOCKING AS REQUIRED
PROTECTED MEMBRANE
MIN. 2% SLOPE TO DRAIN
PREFABRICATED PVC COATED METAL FLASHING
EXPOSED MEMBRANE
MIN. 2% SLOPE TO DRAIN
1 MIN
6
PREFABRICATED PVC COATED METAL FLASHING
DECK MEMBRANE
SLOPED P.T. PLYWOOD BLOCKING
HEAT SEAL DECK MEMBRANE TO FLASHING
50mm (2")
DECK MEMBRANE
SLOPED DECK SHEATHING
EXPOSED MEMBRANE
EXTERIOR EDGES - PEDESTRIAN SURFACE
20

Detail 20: Exterior Edges–Pedestrian Surface

DETAIL 21–RAILING ATTACHMENT AT WALL

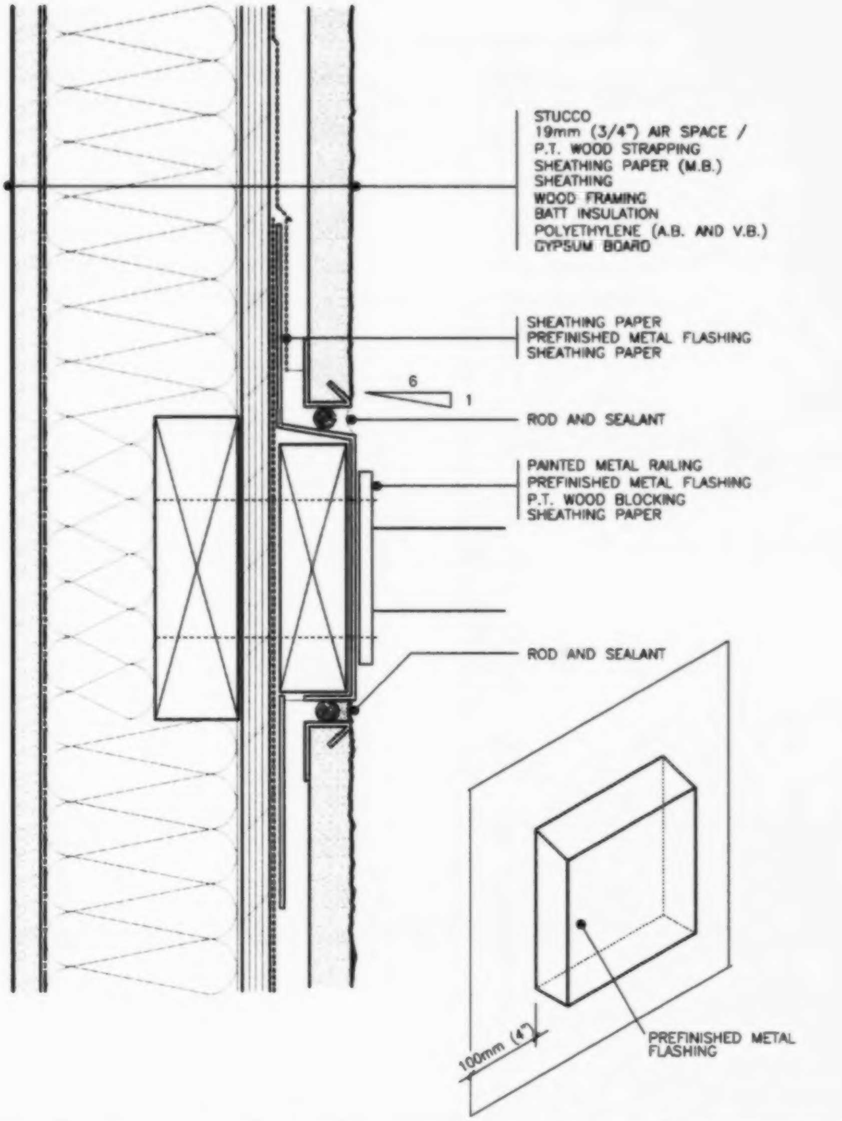
Guards or railings should always be attached to the vertical face balcony fascia, a wall surface or be supported in a manner that does not require fastening through the horizontal deck surface.

Balcony Guard Height

Clause 3.3.1.17 of the *British Columbia Building Code 1998* does not permit guards to be climbable between the heights of 140 mm and 900 mm above the balcony level. If the guard post is mounted on the outside face of a parapet and the top surface of the parapet is climbable, the height of the guard must measure 1070 mm from the top of the parapet, rather than from the balcony floor level.

Sealant

A continuous seal is used between the cladding and the prefabricated metal flashing. Because the seal is continuous, water cannot drain from the cavity at this location. At details such as this it is better to use a continuous caulk joint to reduce the potential for water ingress and force any water in the cavity to drain at another location (possibly with cross slopes on the metal flashing). This strategy is appropriate for small penetrations of the cladding.


STUCCO
19mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. AND V.B.)
GYPSUM BOARD
SHEATHING PAPER
PREFINISHED METAL FLASHING
SHEATHING PAPER
6
1
ROD AND SEALANT
PAINTED METAL RAILING
PREFINISHED METAL FLASHING
P.T. WOOD BLOCKING
SHEATHING PAPER
ROD AND SEALANT
100mm (4")
PREFINISHED METAL FLASHING

RAILING ATTACHMENT AT WALL

21SPA

SEALED POLYETHYLENE APPROACH

Detail 21 SPA: Railing Attachment at Wall–Sealed Polyethylene Approach

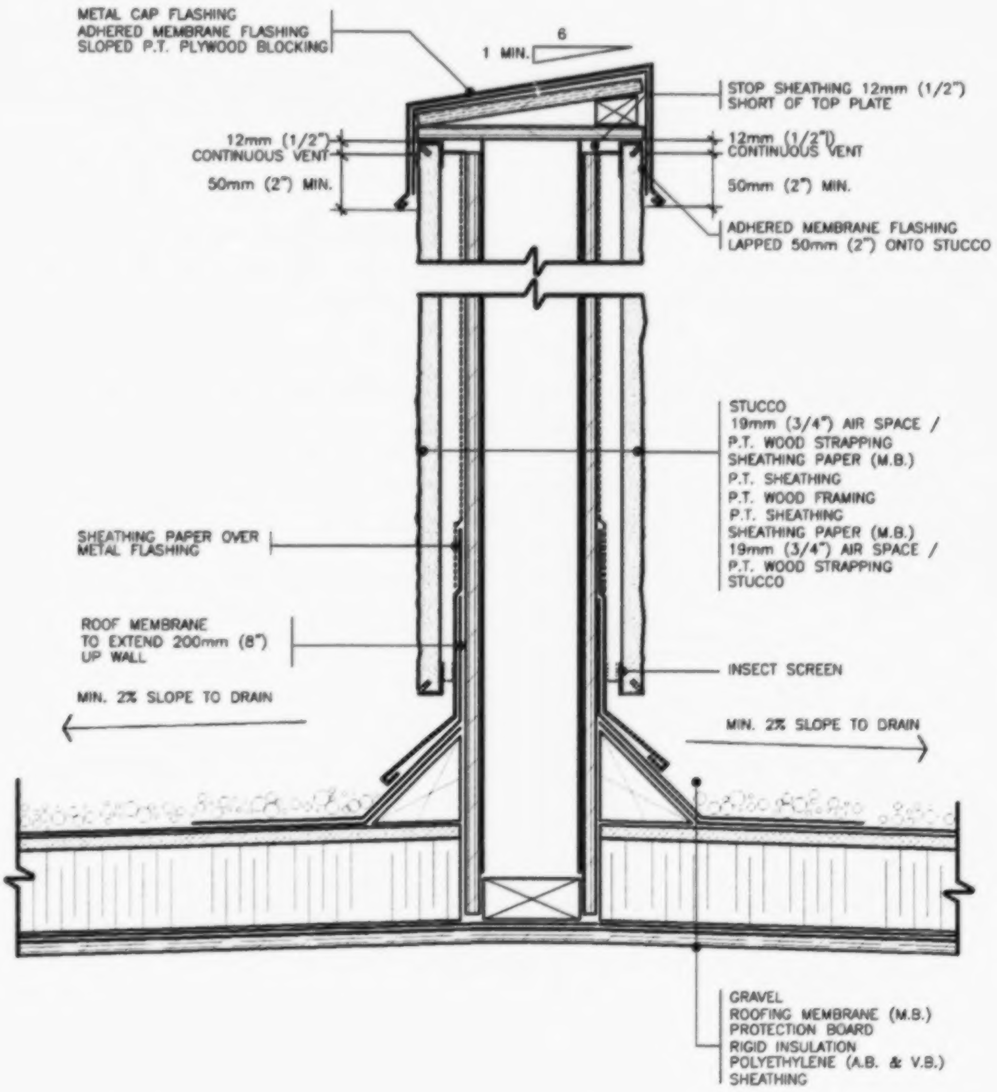
DETAIL 22–EXTERIOR ELEMENT-WALL

Wood Components

It is recommended that all inaccessible wood and structural elements outside the moisture barrier of the main environmental separator be pressure-treated. See discussion in Chapter 2.

Flashing

If the selected roof membrane has an expected performance life of less than the wall system, a two-piece flashing should be utilized. A two-piece flashing will allow replacement of the membrane system without removal of the cladding system.


METAL CAP FLASHING
ADHERED MEMBRANE FLASHING
SLOPED P.T. PLYWOOD BLOCKING
6
1 MIN.
STOP SHEATHING 12mm (1/2") SHORT OF TOP PLATE
12mm (1/2") CONTINUOUS VENT
50mm (2") MIN.
12mm (1/2") CONTINUOUS VENT
50mm (2") MIN.
ADHERED MEMBRANE FLASHING LAPPED 50mm (2") ONTO STUCCO
STUCCO
19mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
P.T. SHEATHING
P.T. WOOD FRAMING
P.T. SHEATHING
SHEATHING PAPER (M.B.)
19mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
STUCCO
SHEATHING PAPER OVER METAL FLASHING
ROOF MEMBRANE TO EXTEND 200mm (8") UP WALL
INSECT SCREEN
MIN. 2% SLOPE TO DRAIN
MIN. 2% SLOPE TO DRAIN
GRAVEL
ROOFING MEMBRANE (M.B.)
PROTECTION BOARD
RIGID INSULATION
POLYETHYLENE (A.B. & V.B.)
SHEATHING

EXTERIOR ELEMENT – WALL 22SPA

SEALED POLYETHYLENE APPROACH

***Detail 22 SPA:** Exterior Element–Wall–Sealed Polyethylene Approach*

DETAIL 23–EXTERIOR ELEMENT–COLUMN

Wood Components

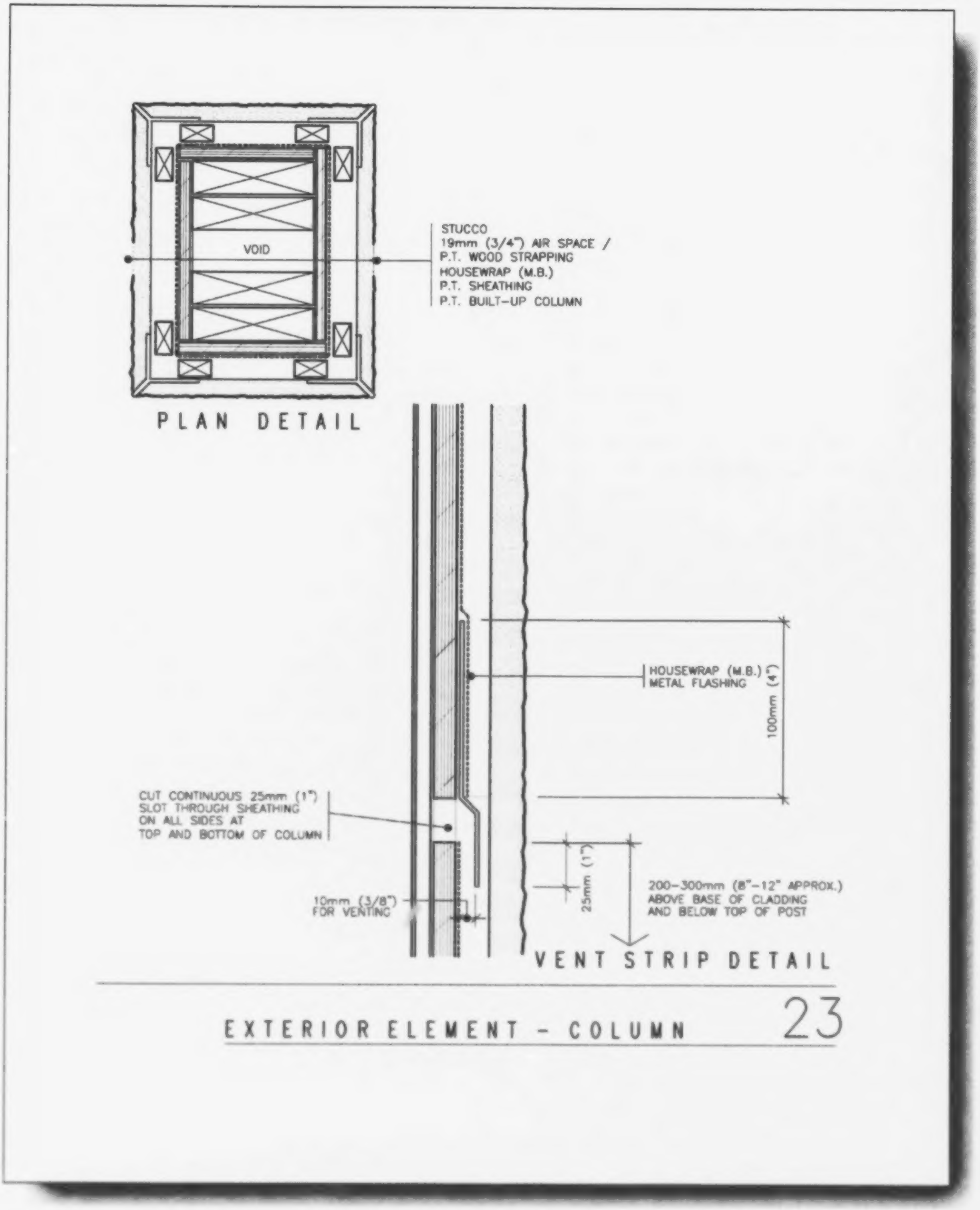
It is recommended that all inaccessible wood and structural elements outside the moisture barrier of the main building envelope be pressure-treated. See discussion in Chapter 2.

Strapping at Corner

Note that a cavity is shown between the two strapping sections at the corners. This cavity is important because corners are one of the most probable locations for water to penetrate the cladding.

Sheathing Membrane

Housewrap is used instead of sheathing paper in this detail. If sheathing paper were used, the self adhering membrane required to protect the paper at corners (see Detail 8, page 6-30) would result in the column being almost completely wrapped in an impermeable material. Housewrap provides sufficient resistance to damage during construction and is more vapour permeable to allow drying.


VOID
STUCCO
19mm (3/4") AIR SPACE /
P.T. WOOD STRAPPING
HOUSEWRAP (M.B.)
P.T. SHEATHING
P.T. BUILT-UP COLUMN
PLAN DETAIL
HOUSEWRAP (M.B.)
METAL FLASHING
100mm (4")
CUT CONTINUOUS 25mm (1")
SLOT THROUGH SHEATHING
ON ALL SIDES AT
TOP AND BOTTOM OF COLUMN
25mm (1")
200–300mm (8"–12" APPROX.)
ABOVE BASE OF CLADDING
AND BELOW TOP OF POST
10mm (3/8")
FOR VENTING
VENT STRIP DETAIL
EXTERIOR ELEMENT – COLUMN
23

Detail 23: Exterior Element–Column

DETAIL 24–GLASS BLOCK–HEAD

Glass Block Installation

To allow the glass blocks to be installed after the framing is complete, the rough opening must be made larger than the glass block panel and polyurethane foam is used to fill the joint.

Structural Design

A structural engineer should design the attachment and support of the glass block panels.

Flashing

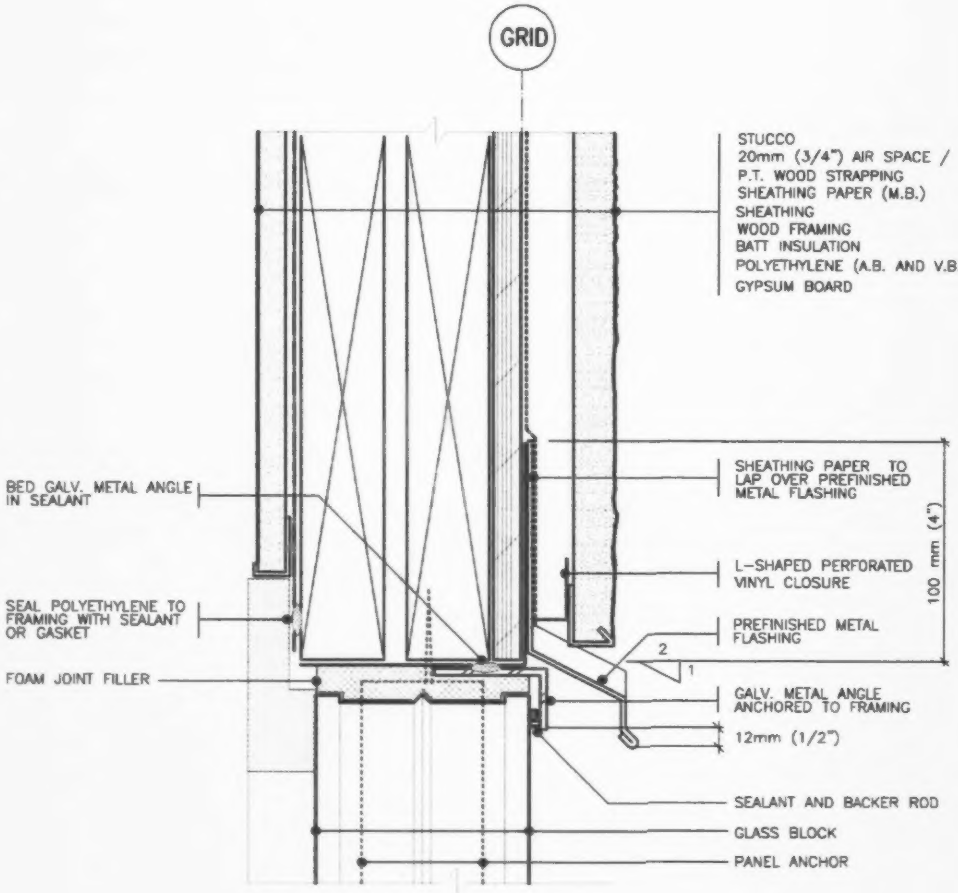
To prevent water running off the end of the flashing and entering the cavity, the head flashing incorporates an end dam. At the jamb, the head flashing should project beyond the end of the glass block panel.

Air Barrier

Air barrier continuity is achieved by connecting the polyethylene to the sheathing paper that returns into the rough opening. The sheathing paper is in turn sealed to the glass block through the urethane foam. This approach can work well if a housewrap type sheathing paper is used. If building paper is used it may be necessary to identify an alternate approach since building paper is not an ideal air barrier material.

Use of Adhered Membrane

The use of excessive amounts of adhered membrane should be avoided particularly at locations that would tend to trap the vertical downward migration of any moisture present. The presence of adhered membrane and polyethylene creates a vapour impermeable pocket from which it is very difficult for any incidental moisture to dry. Therefore, while the use of adhered membrane is advisable at the window sills, and at least part way up the window jambs, its use at window heads should be avoided.


GRID
STUCCO
20mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. AND V.B.)
GYPSUM BOARD
SHEATHING PAPER TO LAP OVER PREFINISHED METAL FLASHING
L-SHAPED PERFORATED VINYL CLOSURE
PREFINISHED METAL FLASHING
100 mm (4")
2
1
GALV. METAL ANGLE ANCHORED TO FRAMING
12mm (1/2")
SEALANT AND BACKER ROD
GLASS BLOCK
PANEL ANCHOR
BED GALV. METAL ANGLE IN SEALANT
SEAL POLYETHYLENE TO FRAMING WITH SEALANT OR GASKET
FOAM JOINT FILLER

GLASS BLOCK - HEAD 24SPA
SEALED POLYETHYLENE APPROACH

Detail 24 SPA: *Glass Block–Head–Sealed Polyethylene Approach*

DETAIL 25–GLASS BLOCK–JAMB

Glass Block Installation

To allow the glass blocks to be installed after the framing is complete, the rough opening must be made larger than the glass block panel and polyurethane foam must be used to seal the joint.

Structural Design

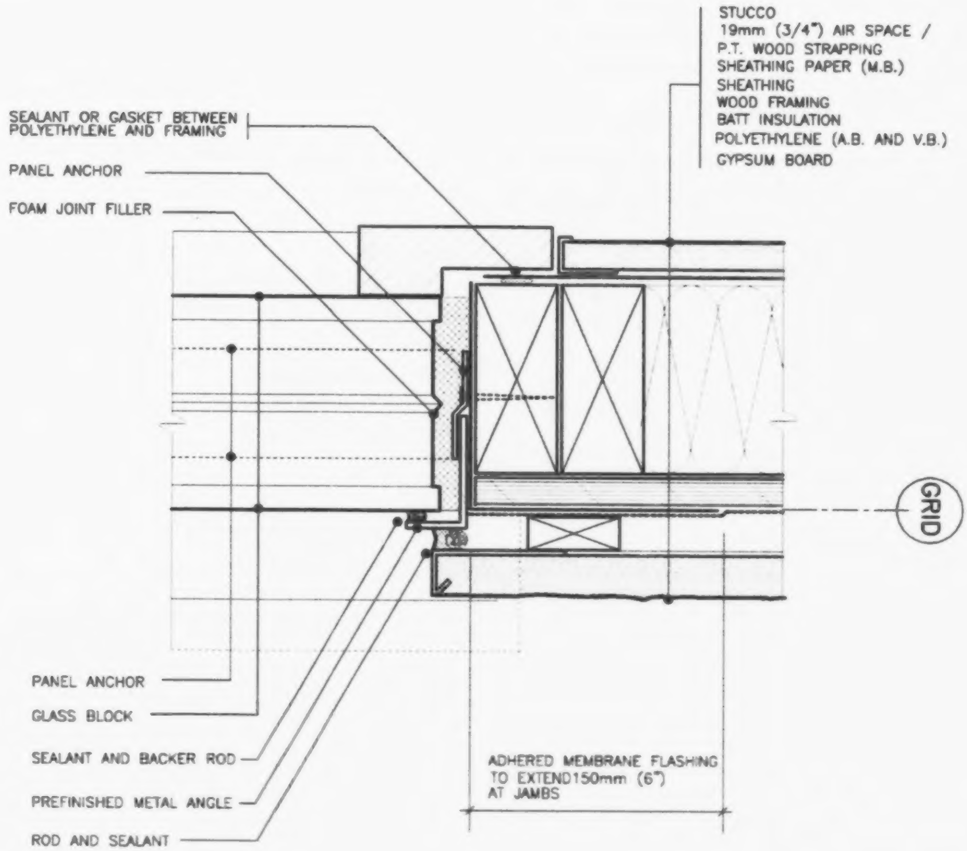
A structural engineer should design the attachment and support of the glass block panels.

Glass Block Attachment

Metal panel anchor straps are typically used to attach glass block panels to wood-frame construction. The anchors are fastened to the vertical face of the wood stud and extend into the horizontal mortar beds between the glass blocks.

Air Barrier

Air barrier continuity is achieved by connecting the polyethylene to the self-adhered membrane, which returns into the rough opening. The membrane is in turn sealed to the glass block through the urethane foam.


STUCCO
19mm (3/4") AIR SPACE / P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. AND V.B.)
GYPSUM BOARD
SEALANT OR GASKET BETWEEN POLYETHYLENE AND FRAMING
PANEL ANCHOR
FOAM JOINT FILLER
GRID
PANEL ANCHOR
GLASS BLOCK
SEALANT AND BACKER ROD
PREFINISHED METAL ANGLE
ROD AND SEALANT
ADHERED MEMBRANE FLASHING TO EXTEND150mm (6") AT JAMBS

GLASS BLOCK - JAMB 25SPA

SEALED POLYETHYLENE APPROACH

Detail 25 SPA: *Glass Block–Jamb–Sealed Polyethylene Approach*

DETAIL 26–GLASS BLOCK–SILL

Structural Design

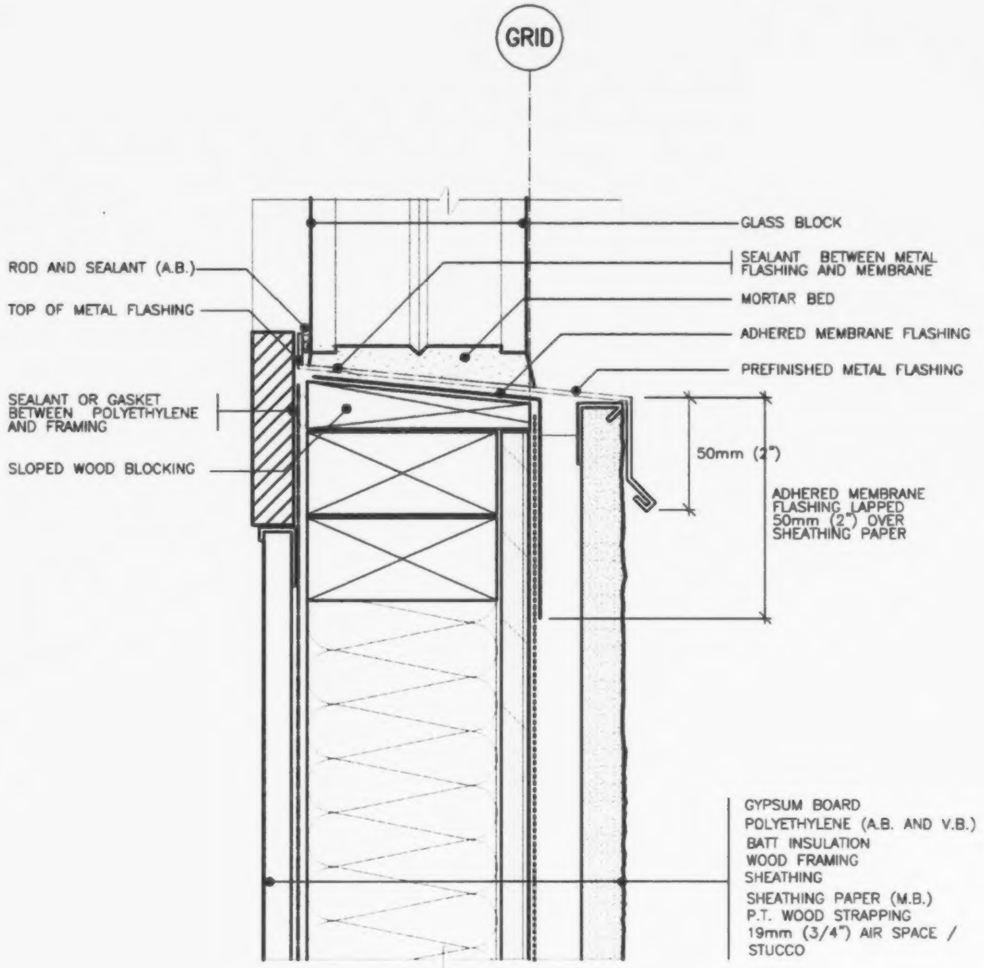
A structural engineer should design the attachment and support of the glass block panels. It may be necessary in some cases to provide additional structural support under the panel. Wood plates on edge are sometimes used for this purpose.

Sill Flashing

A continuous membrane sill flashing is required below the glass block to direct water that penetrates the mortar joint back to the exterior.

Air Barrier

Air barrier continuity is achieved through the polyethylene, wood sub-sill, membrane, metal flashing and sealant into the glass block.


GRID
GLASS BLOCK
SEALANT BETWEEN METAL FLASHING AND MEMBRANE
MORTAR BED
ADHERED MEMBRANE FLASHING
PREFINISHED METAL FLASHING
ROD AND SEALANT (A.B.)
TOP OF METAL FLASHING
SEALANT OR GASKET BETWEEN POLYETHYLENE AND FRAMING
SLOPED WOOD BLOCKING
50mm (2")
ADHERED MEMBRANE FLASHING LAPPED 50mm (2") OVER SHEATHING PAPER
GYPSUM BOARD
POLYETHYLENE (A.B. AND V.B.)
BATT INSULATION
WOOD FRAMING
SHEATHING
SHEATHING PAPER (M.B.)
P.T. WOOD STRAPPING
19mm (3/4") AIR SPACE /
STUCCO

GLASS BLOCK - SILL 26SPA

SEALED POLYETHYLENE APPROACH

Detail 26 SPA: *Glass Block–Sill–Sealed Polyethylene Approach*

DETAIL 27–WALL EXHAUST VENT

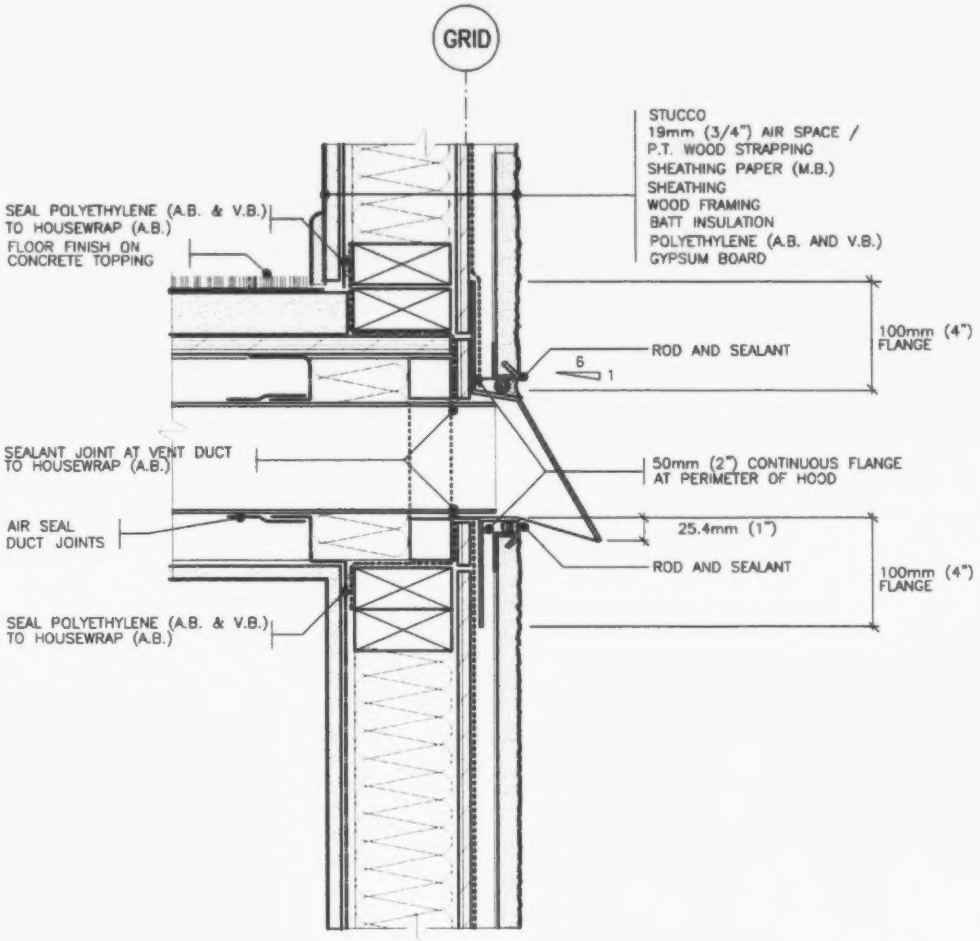
Interior Moisture Sources

Exhaust vent detailing must address two potential moisture sources. Detailing to prevent ingress of rainwater incorporates flashing and the use of sealants. Exhaust vents, particularly from dryers, may also be a source of interior moisture. Significant problems can be caused if hot, humid interior air leaks from ducts, grills, or the connection to exhaust vents, and condenses within wall, floor or balcony assemblies. Care must be taken to ensure that joints in ducts, between ducts and exhaust hoods, and at wall assembly penetrations are airtight.

Flashing

If large numbers of exhaust vents are to be located at rim joists, it may be desirable to integrate the vent flashing with the cross-cavity flashing which typically occurs at this location. The cross-cavity flashing, which in Detail 4 (page 6-14) is located at the level of the wall plates below the joists, may instead be positioned at the level of the top of the rim joist.

The complete installation is shown in the 4-D build illustration, page 6-87.


GRID
STUCCO
19mm (3/4") AIR SPACE /
P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
WOOD FRAMING
BATT INSULATION
POLYETHYLENE (A.B. AND V.B.)
GYPSUM BOARD
SEAL POLYETHYLENE (A.B. & V.B.)
TO HOUSEWRAP (A.B.)
FLOOR FINISH ON
CONCRETE TOPPING
100mm (4")
FLANGE
ROD AND SEALANT
6
1
SEALANT JOINT AT VENT DUCT
TO HOUSEWRAP (A.B.)
50mm (2") CONTINUOUS FLANGE
AT PERIMETER OF HOOD
AIR SEAL
DUCT JOINTS
25.4mm (1")
ROD AND SEALANT
100mm (4")
FLANGE
SEAL POLYETHYLENE (A.B. & V.B.)
TO HOUSEWRAP (A.B.)

WALL EXHAUST VENT 27SPA

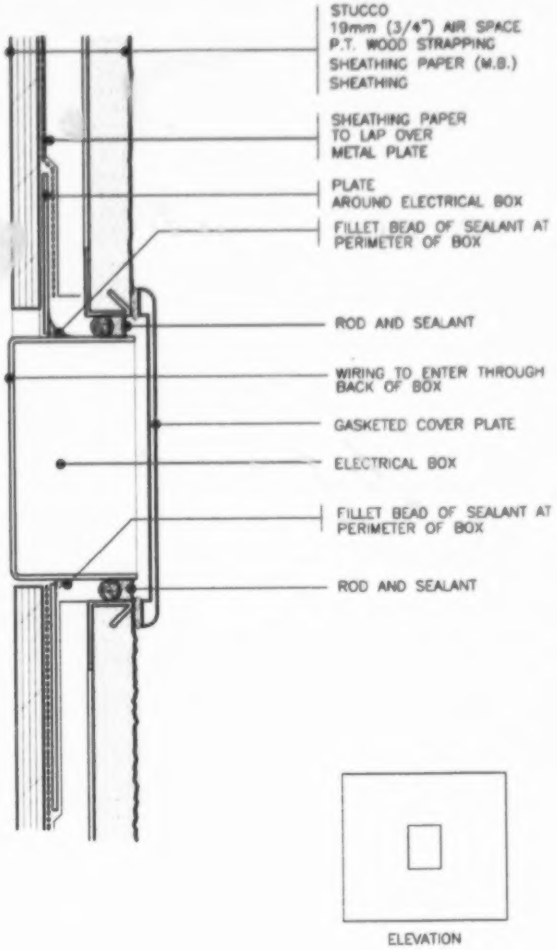
SEALED POLYETHYLENE APPROACH

***Detail 27 SPA:** Wall Exhaust Vent–Sealed Polyethylene Approach*

DETAIL 28–ELECTRICAL FIXTURES

Location of Fixtures

Where possible, fixtures and receptacles should be located in protected areas where the potential for wetting of the adjoining wall surfaces is reduced.


STUCCO
19mm (3/4") AIR SPACE
P.T. WOOD STRAPPING
SHEATHING PAPER (W.B.)
SHEATHING
SHEATHING PAPER TO LAP OVER METAL PLATE
PLATE AROUND ELECTRICAL BOX
FILLET BEAD OF SEALANT AT PERIMETER OF BOX
ROD AND SEALANT
WIRING TO ENTER THROUGH BACK OF BOX
GASKETED COVER PLATE
ELECTRICAL BOX
FILLET BEAD OF SEALANT AT PERIMETER OF BOX
ROD AND SEALANT
ELEVATION

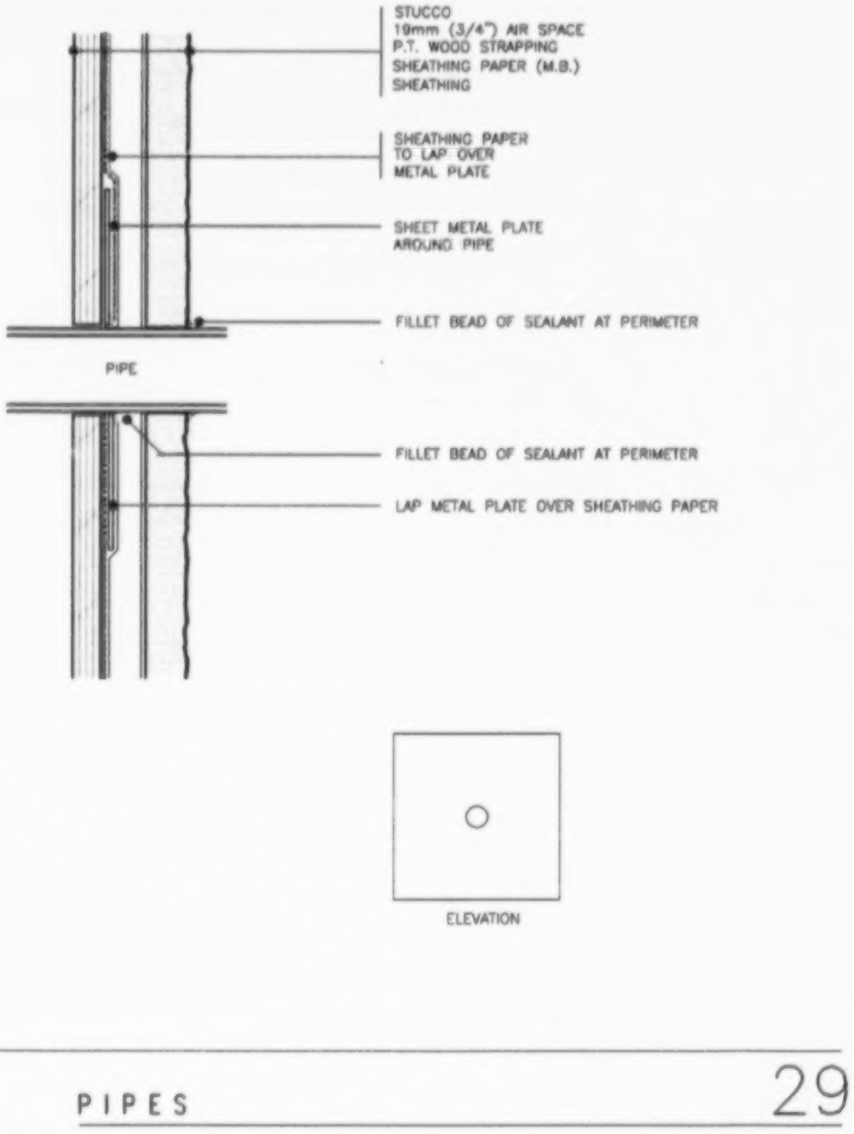
ELECTRICAL FIXTURES 28

Detail 28: *Electrical Fixtures*

DETAIL 29–PIPES

Location of Pipes

Where possible, pipe penetrations should be located in protected areas where the potential for wetting of the adjoining wall surfaces is reduced.


STUCCO
19mm (3/4") AIR SPACE
P.T. WOOD STRAPPING
SHEATHING PAPER (M.B.)
SHEATHING
SHEATHING PAPER TO LAP OVER METAL PLATE
SHEET METAL PLATE AROUND PIPE
FILLET BEAD OF SEALANT AT PERIMETER
PIPE
FILLET BEAD OF SEALANT AT PERIMETER
LAP METAL PLATE OVER SHEATHING PAPER
ELEVATION
PIPES
29

Detail 29: Pipes

4-D DETAILS–WINDOW SILL/JAMB

–WINDOW HEAD/JAMB

–DOOR SILL

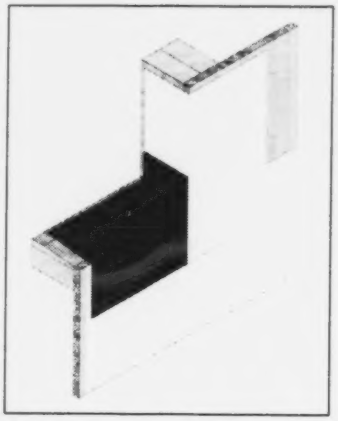
–SADDLE

–EXHAUST VENT

–EXTERIOR STAIRWELL

The 4-D details can also be viewed as animated Microsoft Power Point Build slides on the accompanying CD-ROM:

- Window Sill/Jamb
- Window Head/Jamb
- Door Sill
- Saddle
- Exhaust Vent
- Exterior Stairwell



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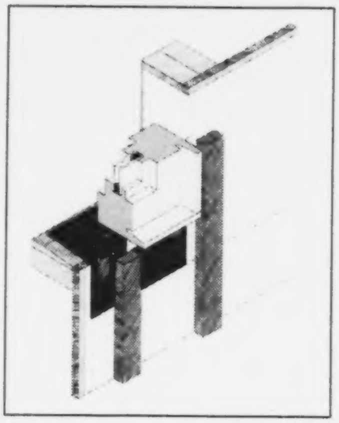

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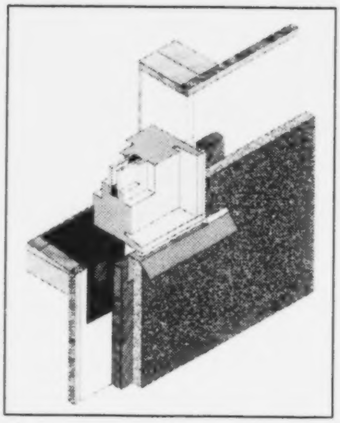

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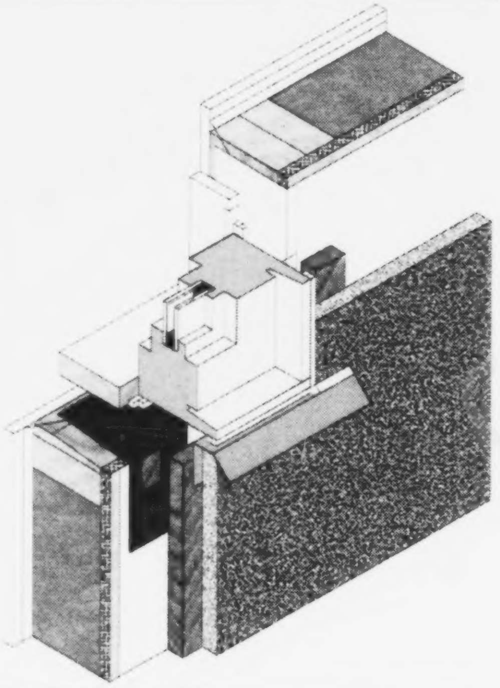
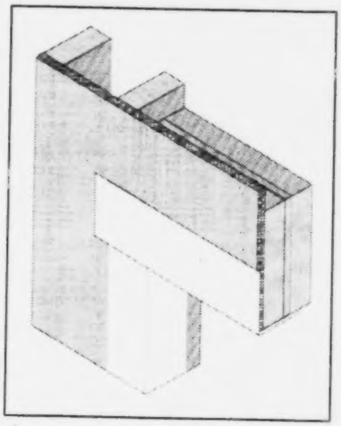


- Framing
- 1
  - Beveled Wood Sub-Sill
  - Wall Sheathing
  - Sheathing Paper
  - Sill Membrane Flashing
  - Corner Membrane Flashing
  - Jamb Membrane Flashing
  - Sheathing Paper
- Wood Shims
- 2
  - Window
  - Sheathing Paper
  - P.T. Wood Strapping
- 3
  - Metal Drip Edge
  - Stucco Cladding (including: Lath, Paper & Accessories)
  - Backer Rod & Exterior Caulking
- Backer Rod & Interior Caulking
- Insulation
- Polyethylene
- Window Sill
- Interior Gypsum Board

Window Sill/Jamb



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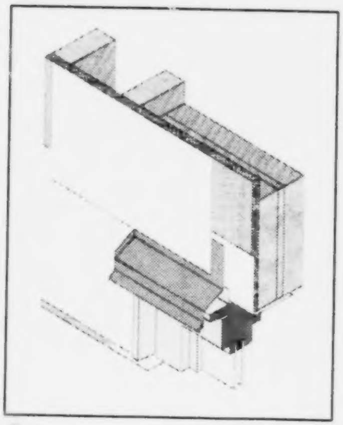

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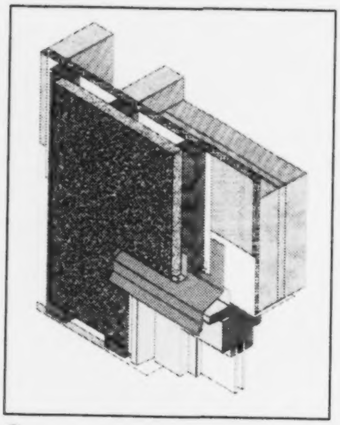

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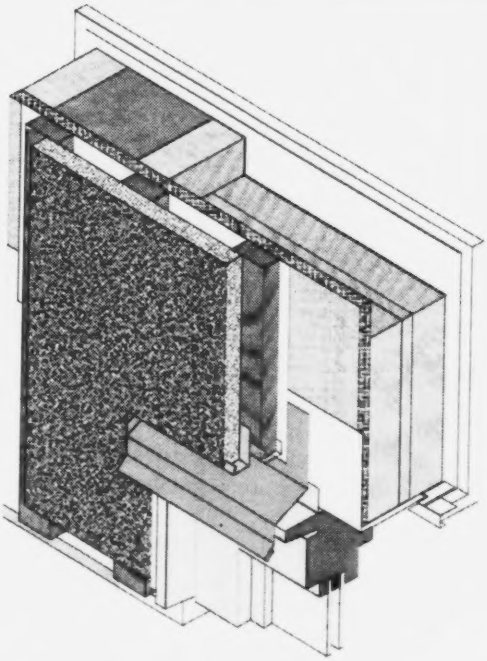


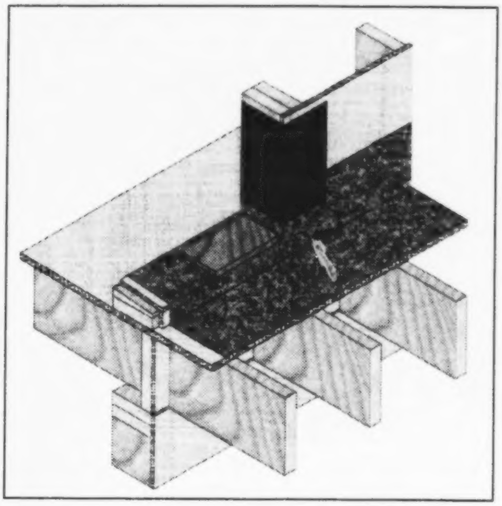
1
- Framing
- Wall Sheathing
- Sheathing Paper at Jam
- Sheathing Paper at Head

2
- Window
- Sheathing Paper
- Metal Head Flashing
- Sheathing Paper

3
- P.T. Wood Strapping
- Insect Screen
- Stucco Cladding (including: Lath, Paper & Accessories)
- Backer Rod & Exterior Caulking

- Insulation
- Polyethylene (Sealed to membrane)
- Interior Gypsum Board

Window Head/Jamb



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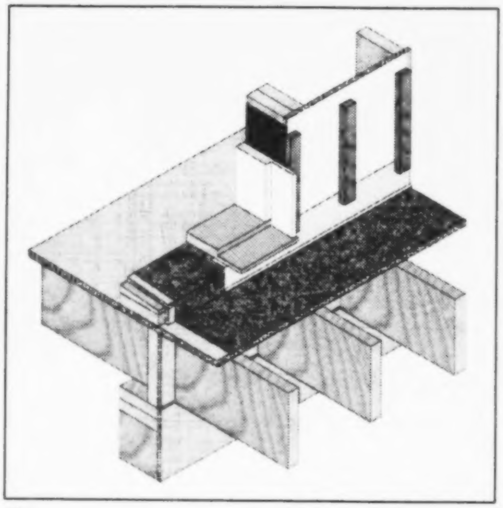

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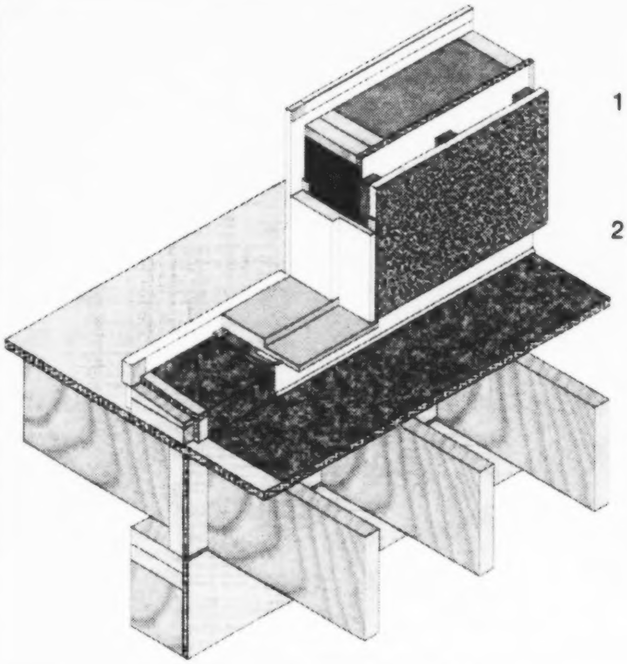
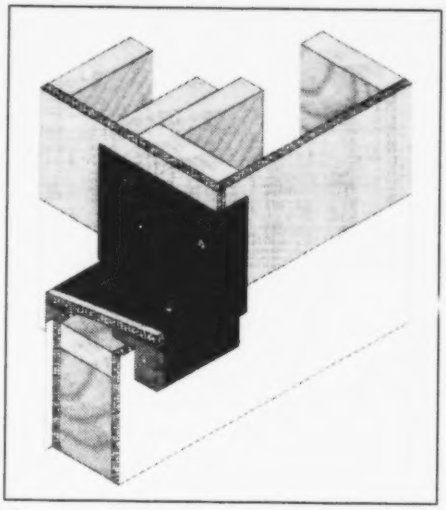


1
- Framing & Deck Sheathing
- Wall Sheathing
- Deck Membrane
- Jamb Membrane Flashing
- P.T. Wood Blocking

2
- Metal Drip Flashing
- Sheathing Paper
- Door
- P.T. Wood Strapping

- Insect Screen
- Stucco Cladding
- Backer Rod & Exterior Caulking
- Backer Rod & Interior Caulking
- Insulation
- Polyethylene (Sealed to door frame)
- Interior Drywall
- Wood Trim

Door Sill



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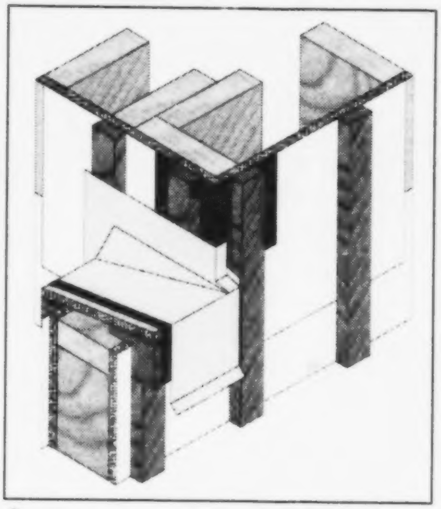

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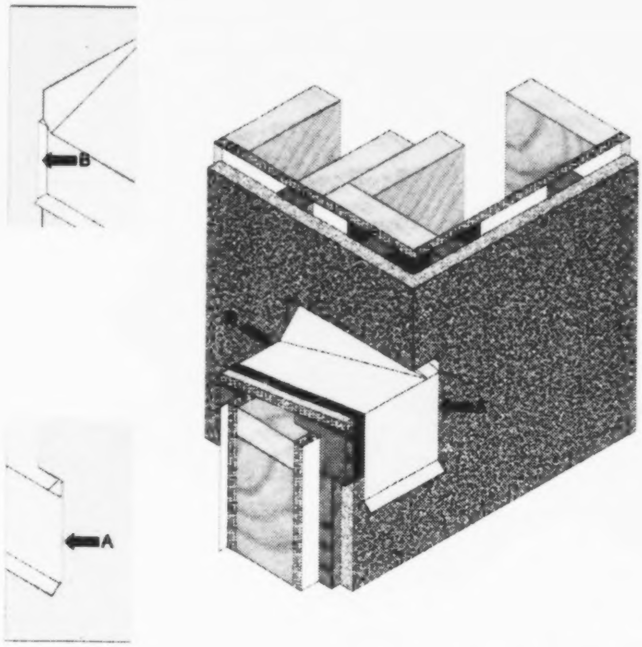
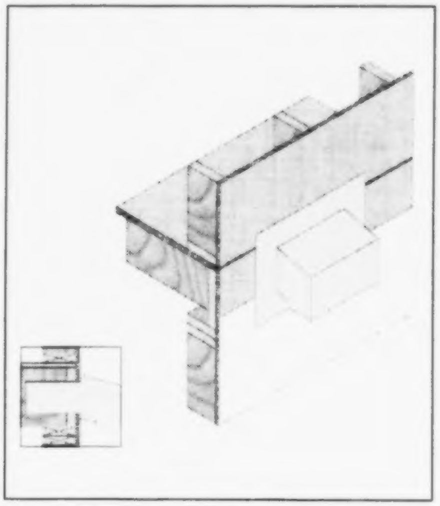


1
- Framing
- Wall Sheathing
- Sheathing Paper
- P.T. Wood Sloped Blocking
- Sloped Blocking Membrane Flashing
- Wall Membrane Flashing

2
- Sheathing Paper
- Corner Membrane Flashing
- P.T. Wood Strapping
- Metal Parapet Flashing

Stucco Cladding
Exterior Caulking

Saddle



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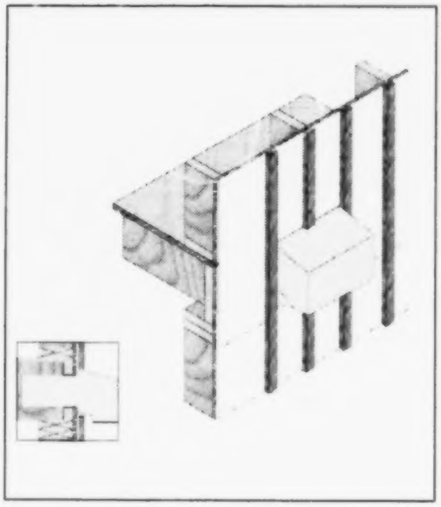

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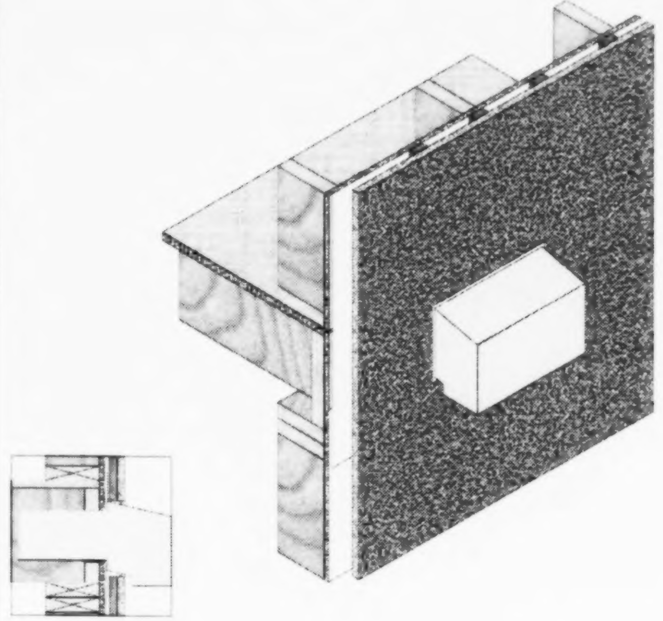
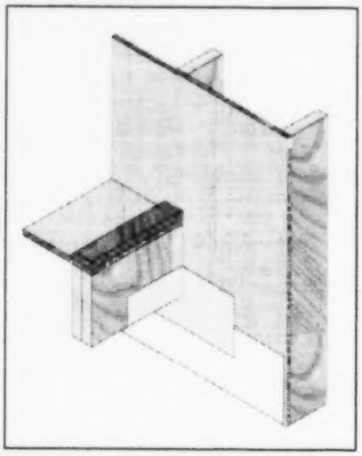


1
Floor & Wall Framing
Exterior Sheathing
Sheathing Paper
One Piece Vent Assembly

2
Sheathing Paper
P.T. Wood Strapping

Stucco Cladding
Backer Rod & Exterior Sealant

Exhaust Vent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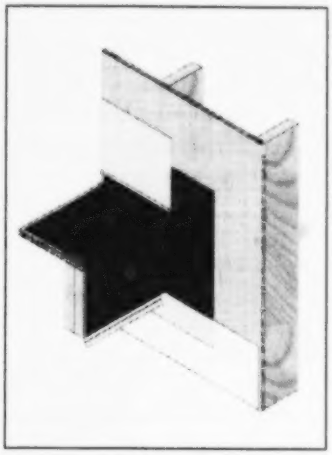
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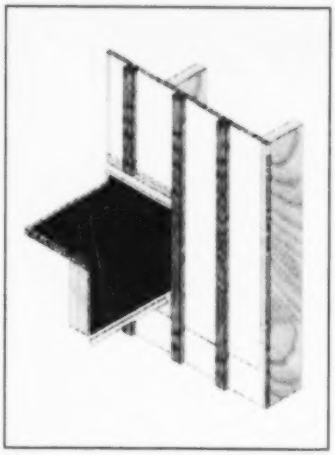
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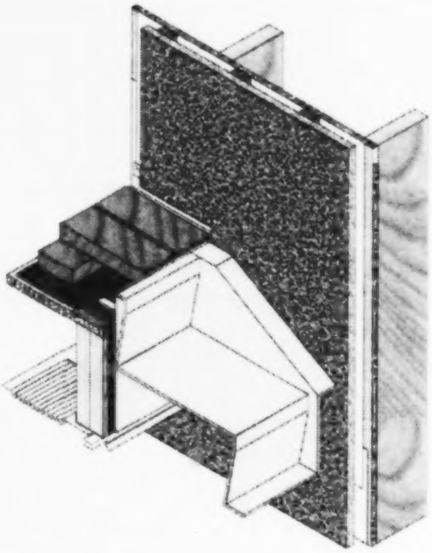

1
- Wall & Landing Framing
- Wood Edge Dam
- Sheathing Paper
- Metal Corner Flashing

2
- Metal Drip Flashing
- Landing Waterproofing
- Metal Drip Flashing

3
- Sheathing Paper
- P.T. Wood Strapping
- Insect Screen

Stucco Cladding
Metal Stair Assembly
Membrane Strip Over Metal
Stair Assembly Flange
P.T. Wood Decking
Vented Soffit or Rated Assembly
As Required

Exterior Stairwell

CHAPTER 7

COMPONENTS AND MATERIALS

SCOPE

This section links the assembly and drawing details in Chapters 5 and 6 with the project specifications. It provides guidance so informed decisions can be made when selecting or specifying components and materials for the building envelope. This information is intended to be used to customize commercially available master specification and software packages. These master specifications are available from industry associations and professional master specification organizations. They are continually updated to include the most recent versions of applicable standards and codes. Wherever possible, appropriate master specifications and other design and selection reference material are listed.

Most, but not all, of the components and materials referenced in the details and assemblies are discussed in the following sections.

WOOD PRODUCTS

Wood and its properties are discussed in detail in Chapter 2 of this Guide. It is important that the most appropriate wood product be used in each application to maximize the life of the structure. Table 7.1 outlines the recommended wood species, grades and preservative treatments for various service environments.

Although the *Survey* was not able to establish differences in the prevalence of moisture problems in wall assemblies constructed with oriented strandboard or plywood, the types of oriented strandboard commonly used in wood-frame construction are known to swell more than plywood when wetted. It is not appropriate to use any sheathing material (wood or non-wood) directly in contact with cladding that is likely to retain moisture. A sheathing membrane must be used to separate the cladding from the sheathing. A drainage cavity is recommended in medium-to-high-exposure conditions.

Note that the cut ends of all pressure-treated wood applications listed in Table 7.1 should be field treated with a copper napthanate solution.

Table 7.1: Wood Product Selection Guide

Service Environment	Conditions of Service	Wood Product	Treatment
Roof shingles/shakes	Normal Exposure	No.1 (blue label) Western red cedar	Although Western red cedar is a durable wood species, treatment with CCA to CSA 080.2 will greatly increase longevity.
	Under trees	Same	Chromated copper arsenate pressure treated to CSA 080.2
Roof sheathing	Well vented attic space (large vents at ridge and soffits and open attic space for convection combined with functional air barrier between building and attic)	Plywood or OSB	None required
	Cathedral roofs, vented flat roofs or other moderately vented attic spaces.	Plywood	Pressure preservative treatment with borate or chromated copper arsenate to AWPS C9-907 or CSA 080.9
Exterior balconies and walkways over non living space	Plywood, framing, installed under membrane	Lumber, Plywood, Hem-Fir, SPF, plywood, D.F.-L, Northern species	S-Dry
	Exposed wood decks and exposed duck boards over inverted roof membranes	Western red cedar, or yellow cedar, or treatable species	Chromated copper arsenate pressure treated to CSA 080.34 if not a naturally durable species
Roof framing	All roofs	Lumber, trusses, composite beams	S-Dry
Wall framing	Outer walls	Lumber, SPF, Hem-fir, D.F.-L., Northern species	S-Dry
	Framing, joists, balcony railings and support posts that are inaccessible and installed outside the moisture environmental separator	Treatable species	Pressure preservative treat with borate to CSA 080.34 or chromated copper arsenate to CSA 080.2
	Wood plates in contact with grade level concrete	Treatable species	Pressure preservative treat with borate or chromated copper arsenate
Wall sheathing	Outer walls	Plywood, solid wood or OSB	Keep dry on site
	Outside moisture environmental separator	Plywood, treatable species	Chromated copper arsenate pressure treated to CSA 080.9 (plywood) or CSA 080.2 (lumber)

Table 7.1: Wood Product Selection Guide (continued)

Service Environment	Conditions of Service	Wood Product	Treatment
Strapping	Cavity walls (vented cavity outside the moisture barrier)	Treatable species	Chromated copper arsenate pressure treated to CSA O80.2, 4kg/m^3, treated individually, not to be cut from larger stock
Cladding, fascia and trim	Exterior exposure	Western red cedar, yellow cedar	Back-primed, exterior prime and paint or stain
		Treatable species	Chromated copper arsenate pressure treated, prime and paint or stain
Interior finishes	All applications	Appearance lumber	Kiln dried to 8 per cent MC, keep dry on site
Window joinery	Exterior exposure	Typically, Ponderosa pine, white pine, Hem-Fir, Douglas fir	Pressure treated with tri (n) butyl tin oxide, factory primed and painted
Floor framing	Crawl space close to grade	Treatable species	Chromated copper arsenate Pressure treated to CSA O80.2, 4kg/m^3
	Indoor exposure	Lumber, floor trusses, composite beams	S-Dry
	Rim joists in close proximity to grade level concrete	Treatable species	Pressure preservative treat with borate or chromated copper arsenate
Sub-flooring	Crawl space close to grade	Treatable species	Pressure preservative treat with borate or chromated copper arsenate to AWPA C9-97
	Indoor exposure	OSB, plywood, solid wood	Dry
Below grade, ground contact, permanent wood foundation	Well drained, porous backfill	Treatable species	Chromated copper arsenate pressure treated to CSA O80.15
Direct ground contact	Exterior exposure	Treatable species	Chromated copper arsenate pressure treated to CSA O80.2, 6.4 kg/m^3

INSULATION

Thermal insulation reduces heat loss in the winter and heat gain in the summer. In addition, depending on the type of insulation, it can act as fire proofing or it can reduce noise transmission, air leakage and vapour flow. The selection of the insulation must be based on a combination of factors including the required thermal resistance, the durability, the installed environment, the required vapour permeance, flame spread requirements and sound transmission properties. Table 7.2 is a general guide for the selection of a particular class of insulation. Once a specific insulation class is identified for use, consult the manufacturer's literature for more detailed and accurate information on the specific products available.

Table 7.2: Typical Insulation Properties

Type	Typical Properties	Typical Uses
Glass Fibre Insulation (Batt)	RSI= 2.0 @ 89 mm Resistance to vapour flow: Low Resistance to air flow: Low Fibre type: Inorganic Combustibility: flame spread rating<25	• Between studs in wood and steel stud walls • Between joists or trusses in attic spaces • Perimeter of windows and doors
Glass Fibre Insulation (Rigid)	RSI= 0.73 @ 25 mm Resistance to vapour flow: Low Resistance to air flow: Low Fibre type: Inorganic Combustibility: flame spread rating<25	• Cavity walls on the exterior of the sheathing membrane • Curtain wall backpans • Under waterproof roof membranes • Insulation around piping
Cellular Glass	RSI= 0.55 @ 25 mm Resistance to vapour flow: High Resistance to air flow: High Fibre type: Inorganic	• Roof insulation for conventional roof systems • On the interior of concrete walls
Mineral Wool Insulation CAN/ULC-S702	RSI= 0.60 @ 25 mm Resistance to vapour flow: Low Resistance to air flow: Low Fibre type: Inorganic Combustibility: flame spread rating<25, non-combustible	• Between joists or trusses in attic spaces • Insulation around piping • Insulation around heating ducts and pipes • Rigid boards used in cavity walls on exterior of wall membrane • Curtain wall backpans, EIFS wall assemblies
Expanded Polystyrene (beadboard) CAN/ULC-S701	RSI= 0.69 @ 25 mm Resistance to vapour flow: Med. Resistance to air flow: Med. Material type: Organic Combustibility: Varies	• Cavity walls on the exterior of the sheathing membrane • Roof insulation for conventional roof systems • Concrete wall insulation below ground in well-drained areas • EIFS wall assemblies

Table 7.2: Typical Insulation Properties (continued)

Type	Typical Properties	Typical Uses
Extruded Polystyrene CAN/ULC-S701	RSI= 0.88 @ 25 mm Resistance to vapour flow: Med. Resistance to air flow: Med. Material type: Organic Combustibility: Varies	• Cavity walls on the exterior of the sheathing membrane • Roof insulation for inverted roof systems • Concrete wall insulation below ground • Under concrete slabs on grade
Polyurethanes CGSB 51-GP-21M	RSI= 0.97 to 1.1 @ 25 mm Resistance to vapour flow: High Resistance to air flow: High Material type: Organic Combustibility: Varies	• Cavity walls on the exterior of the sheathing • Roof insulation for conventional roof systems • Spray-on capabilities for wall cavity, roofing, and air barrier applications, perimeters of windows and doors
Polyisocyanurate CGSB 51-GP-21M	RSI= 0.97 to 1.1 @ 25 mm for permeable facings; RSI=1.27 @ 25 mm for impermeable facings Resistance to vapour flow: Med. Resistance to air flow: Med. Material type: Organic Combustibility: Varies	• Cavity walls on the exterior of the sheathing membrane • Roof insulation for conventional roof systems
Cellulose Fibre CAN/CGSB-51.60M	RSI= 0.55 to 0.65 @ 25 mm Resistance to vapour flow: Low Resistance to air flow: Low Material type: Organic Combustible	• Between wood studs in walls • Between joists or trusses in attic spaces

SHEATHING MEMBRANES

SHEATHING MEMBRANES–BREATHER TYPE

Design and Selection References:

- CAN 2-51.32 Sheathing Membrane, Breather Type
- CMHC, Canadian Wood-Frame House Construction

Breather type membranes are permeable to water vapour and will allow some drying from the interior of the wall to the exterior for very small quantities of residual construction moisture or condensation in the wall assembly. The Canadian standard CAN2-51.32-M requires breather type membranes to have permeability ratings in the order of 170 ng/Pa•s•m2 (2 perms) to 1400 ng/Pa•s•m2 (16 perms). Because these membranes are permeable to vapour, they are not intended to be used as vapour retarders in the wall assembly. Breather type membranes are not usually fully adhered to the sheathing. Typical breather type membranes include building papers and housewrap products.

Because of their inherent material properties, breather type membranes do allow water to move through the membrane if they are exposed to liquid water for long periods of time. The Canadian standard does not require a minimum level of watertightness. The rate at which liquid water moves through the membrane is typically measured using a water resistance test or "boat test". This test is performed by measuring the amount of time it takes for water to diffuse through the material and affect an indicator dye when the opposite side is in full contact with water. Asphalt impregnated organic breather type membranes (building paper) tested to this standard have ratings which usually vary between 30 to 60 minutes.

Housewraps such as spun bonded olefin membranes are typically much more vapour permeable than sheathing papers but have a better resistance to movement of liquid water. As a result, these products do not perform well in the boat test, because the high vapour permeability allows for quick movement of vapour through the membrane. Manufacturers of these types of membranes typically use a water column test. This involves sealing a sample of membrane to the base of a hollow column. Water is then poured into the column and the height of water and time is measured until water is observed on the dry side of the membrane. Typically spun bonded olefin membranes perform better than building papers in this test because of the small pores in the membrane and the better water saturated strength of the membrane. Care must be taken with these membranes in the presence of surfactants such as soap and form release agents. Contact with surfactants will reduce the membranes' resistance to water penetration. The effect of surfactants is also observed to a lesser degree with sheathing papers. Spun bonded olefin membranes can be sealed at joints and used as an air barrier in low-rise construction. In order to achieve an effective air barrier, the membrane must be sealed and it must have sufficient support in both the infiltrating and exfiltrating direction to prevent damage to the membrane or joint failure under wind loads.

Other housewrap products such as perforated polyethylene membranes usually fall somewhere between sheathing papers and spun bonded olefin membranes in terms of vapour permeability and resistance to liquid water. The properties of these products will vary with the size and number of holes that are perforated though the base sheet. Resistance to liquid water will usually decrease as the vapour permeability increases. Consult manufacturer's literature for water resistance and vapour permeability information.

All of the membranes in this class have the potential to perform their function, provided that their exposure to liquid water is incidental and sufficient drying time is allowed between wettings. Sheathing membranes are often incorrectly used to protect wood in flat or low slope applications. Sheathing membranes do not work where there is any chance of liquid water ponding, generally this means acceptable use on vertical surfaces only. For applications where the slope is not vertical, a waterproof sheathing membrane should be used.

Currently the industry has moved towards the use of either a 60-minute sheathing paper, or 2 layers of a 30-minute sheathing paper as the standard for most wall assemblies and exposure conditions. In practice, the application of one layer of 60-minute paper is more economical from a labour standpoint and allows for simpler detailing at intersections. At this time, there does not appear to be a clear performance benefit to the use of one or two layers of sheathing membrane. The additional layers provide greater resistance to inward moisture movement but also further restrict movement of moisture out of the wood sheathing layer.

Performance problems have been experienced with spun bonded olefin membranes and perforated polyethylenes behind face sealed and concealed barrier assemblies in medium and high exposure environments. However, they are appropriate for use in rainscreen assemblies for low and medium exposure, or in face sealed and concealed barrier assemblies for low exposure conditions.

Just as important as is the selection of the membrane, the installation and detailing of the membrane are critical to performance. Care must be taken to ensure that the membrane is shingled from the top of the building to the lowest cross cavity flashing. Details in this Guide provide examples of penetrations, however, this breather type sheathing membrane is typically used in conjunction with metal flashings, waterproof membrane or manufacturer's joint tape to effectively manage moisture and/or air leakage.

SHEATHING MEMBRANES – WATERPROOF

Waterproof sheathing membranes are also commonly referred to as air barrier membranes or non-breather membranes. These materials are typically fully adhered to the exterior sheathing and are located such that some or all of the wall insulation is placed to the membrane's exterior, in order to control condensation. The most common materials used for this class of membrane are sheets of self-adhesive modified bituminous membranes, but can also consist of liquid applied polyurethane or bituminous membranes. Because of their ability to fully adhere to the sheathing, these membranes are ideally suited to providing the primary airtightness plane for buildings. The materials used in the manufacture of these products are highly impermeable to water vapour and the joints between membranes can be sealed to create a watertight barrier. This allows these membranes to manage large and frequent volumes of water while still keeping the wall assembly dry. Their successful use is contingent on condensation management. As the membrane is a vapour barrier, it must be placed on the interior of a sufficient amount of insulation to prevent the accumulation of condensation. All intersections must be adequately detailed to prevent air and water leakage through the membrane. Some are shown in Chapter 6.

Membranes need reinforcement to allow bridging of cracks and small gaps in the substrate. Most often this is a sheet of polyethylene on the exterior surface or a polyester sheet embedded between two layers of liquid applied membrane. Membranes used in this application are typically a minimum of 1 mm (40 mil) thick.

The adhesion of the membrane should be verified for the conditions under which it will be applied. Many products do not adhere to some common substrates such as fibreglass faced sheathings. The application of primer will greatly improve the bond of the membrane in all conditions. Use a low temperature grade of membrane during the colder times of the year. Primer is the base membrane (or similar product) dissolved in solvent. The solvent must be allowed to evaporate completely before the membrane is installed. Otherwise the solvent that is trapped will dissolve the membrane above. Do not use waterproof membranes and primers with other manufacturers' products without first checking with the respective manufacturers for possible chemical incompatibilities.

Most problems occur at terminations or laps in these membranes. Terminations between the membrane system and other wall components or assemblies should be clamped with a fastening bar or sealed with mastic, depending on the joint. Membrane terminations which are lapped opposing the flow of water (not shingled) or which are close to movement joints should be clamped with a fastening bar and sealed. Lapped joints that are less than the manufacturers' minimum, are reversed lapped or are located in a horizontal or low-sloped application should be coated with a generous amount of membrane mastic or a compatible liquid membrane product.

FLASHINGS

The selection and design of flashings is covered in detail in Chapter 1 of *Best Practice Guide: Flashings*. The following is a brief summary of the major types of flashing and materials.

Most flashing is made from the following materials:

- metal,
- polyvinyl chloride (thermoplastic),
- ethylene propylene diene monemer (thermosetting),
- bituminous and modified bituminous membrane.

A comparison of the various types of commonly used flashings is presented in Table 7.3.

Metal Flashing

Metal flashing is most commonly used as a counter flashing. Metal can be durable, resistant to ultra-violet light and physical damage. The most important aspect of metal flashing is the joint. Because metal flashing expands and contracts with temperature, the joints must be capable of accommodating movement while maintaining their water-tightness. The simplest method of reducing leakage at the joints in metal flashing is to provide a large slope to the exterior. Flashing with slopes in the order of 2:1 reduce the risk of a back slope or cupping as well as the amount of water contacting the joint. Provided that high slopes are used, a simple S lock (Figure 7.1) or lap joint in the flashing can effectively shed water. Since the movement between flashings is quite large, sealant placed at the joints will fail quickly unless a bond breaker tape and bandage type sealant joint is used to accommodate the movement, as shown in Figure 7.1. At outside and inside corners, or where slopes are less than 2:1, flashings can be either soldered/welded and prepainted, or a standing seam joint (Figure 7.2) can be used to make the joints water resistant.

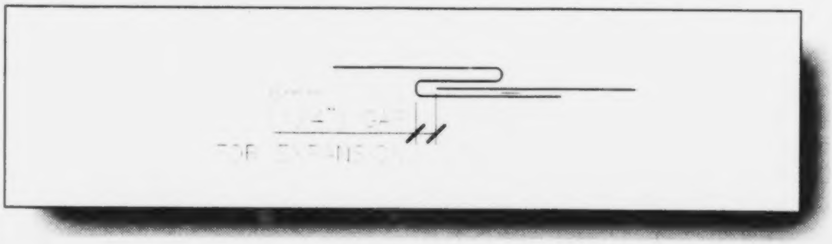

Figure 7.1: 'S' Lock joint

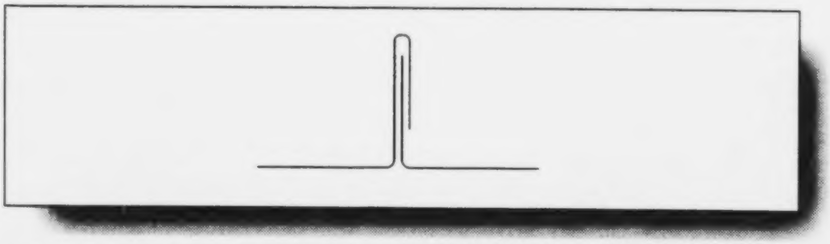

Figure 7.2: Standing seam joint

Table 7.3: Comparison of Flashing Materials

Material	Application	Minimum Thickness	Comments
Aluminum	Wall flashing Counter/cap flashing Valley flashing	0.48 mm (0.019 in.) 0.48 mm (0.019 in.) 0.48 mm (0.019 in.)	• Pliable and soft, corrosion-resistant and non-staining. Cannot be soldered. • High coefficient of expansion (higher than steel). • Cannot be used in direct contact with mortar and concrete. Must be coated with bituminous material if it is to be placed adjacent to concrete. Cannot be used in salty and polluted environments. • Deteriorates in contact with other metals. Can only be used with aluminum or stainless steel fasteners.
Copper	Wall flashing Counter/cap flashing Valley flashing	0.36 mm (0.014 in.) 0.46 mm (0.018 in.) 0.46 mm (0.018 in.)	• Easy to work with, durable and resistant to corrosion although susceptible in salty environments. • Easily cold rolled. • Cannot be used in direct contact with concrete or mortar. • Changes to form a pale green patina colour and may stain adjacent materials. • Must not come in contact with dissimilar metals except lead.
Type 304 stainless steel	Wall flashing Counter/cap flashing	0.33 mm (0.013 in.) 0.33 mm (0.013 in.)	• Durable, resistant to corrosion and maintenance-free. • Not adversely affected by mortar or concrete.
Zinc	Wall flashing Counter/cap flashing Valley flashing	0.46 mm (0.018 in.) 0.46 mm (0.018 in.) 0.46 mm (0.018 in.)	• Durable. • Not adversely affected by mortar or concrete. • Cannot be used in contact with steel unless as a sacrificial anodic coating as in galvanized steel. • Corrodes in salty or acidic environments (acid rain).
Galvanized steel	Wall flashing Counter/cap flashing Valley flashing	0.38 mm (0.015 in.) 0.38 mm (0.015 in.) 0.38 mm (0.015 in.)	• Easy to work with, economical, durable and stain resistant. • Low coefficient of expansion. • Not adversely affected by mortar or concrete. • Do not use in direct contact with copper or aluminum. • Subject to corrosion in acidic or salty air. • Thickness of zinc coating must be specified. Refer to specification.

Table 7.3: Comparison of Flashing Materials (continued)

Material	Application	Minimum Thickness	Comments
Flexible rubberized asphalt or modified bituminous membrane	Wall flashing Counter/cap flashing (granulated) Valley flashing (granulated)	0.75 mm to 3 mm (0.030 in. to 0.120 in.)	• Select heat-welded or self adhesive type compatible with air barrier. Easy to seal and make watertight. • Deteriorates with exposure to sunlight unless protected by mineral granules. • Temperature and moisture sensitive installation. • Verify with manufacturer for compatibility with sealants, solvents, adhesives, etc.
Lead, lead-coated copper	Wall flashing Counter/cap flashing Valley flashing	1.73 mm (1/16 in.) 1.73 mm (1/16 in.) 1.73 mm (1/16 in.)	• Extremely malleable, resistant to atmospheric corrosion, non-staining. • Paintable. • Very high coefficient of expansion, easily punctured. • Cannot be used in contact with uncured mortar or concrete. • Should be avoided because of the toxicity of the material.
Ethylene propylene diene monemer membrane	Wall flashing Counter/cap flashing Valley flashing	1 mm (40 mil) reinforced	• Taped or solvent sealed seams. • Check with manufacturer to ensure membrane can be exposed to direct sunlight. • Susceptible to physical damage during installation of adjacent materials. • Verify with manufacturer for compatibility with sealants, solvents, adhesives, etc.
Polyvinyl chloride membrane	Wall flashing Counter/cap flashing Valley flashing	1 mm (40) mil reinforced	• Heat welded seams are easy to make permanently watertight. • Resistant to ultraviolet light. • Most resistant of the membrane type flashings to physical damage during installation of adjacent materials. • There is a full range of compatible polyvinyl chloride coated metal flashings that makes the transition to metal flashings easy and watertight. • Membrane can be custom colored.
Reinforced polyethylene	Wall flashing	0.15 m (0.006 in.)	• Difficult to seal laps, should be used only in concealed locations. • Not recommended.
Copper or aluminum laminated to felt or Kraft paper	Wall flashing	0.15 m to 0.5 mm (0.006 in. to 0.02 in.)	• Difficult to seal joints, should be used only in concealed locations. • Poor durability. • Not recommended.

It is difficult to make waterproof joints in metal flashings. A waterproof membrane flashing should always be applied under segmented metal flashings to protect the wall in the event of a joint failure. This base flashing should always be lapped over the wall sheathing membranes.

Penetrations through metal cap flashing, at nailing posts, for instance, provide a direct access point for moisture. This practice is not recommended. Railings should be attached to the walls below the cap flashing.

Polyvinyl Chloride (Thermoplastic) Flashing

Polyvinyl chloride (PVC) flashing can be used as either a base or counter flashing. It is a moderately durable material, resistant to ultraviolet light and can be heat welded at the joints, reducing the potential for leaks at this critical location. PVC flashing can also be easily integrated with PVC coated metal flashing and roof and deck membranes of the same material. This allows intersections to be welded together, increasing the watertightness of the intersections with other building components.

Ethylene Propylene Diene Monemer (Thermosetting) Flashings

Ethylene propylene diene monemer (EPDM) flashings are used as base flashings in masonry construction, built-in gutters and EPDM roofing. These flashings are resistant to ultra-violet and are sealed at joints using a lap sealing compound. EPDM flashing is particularly susceptible to physical damage both during and after construction. This is a concern in masonry construction as masonry units are set in place and in exposed gutter applications where the flashings are exposed to sliding snow and ice. Ethylene propylene diene monemer flashing is not easily integrated with adjacent materials such as metal flashings and polyvinyl chloride deck membranes.

Bituminous and Modified Bituminous Membranes

These materials are most often used as a base flashing in roofing and for wall flashing in cavity wall construction. This flashing can be made permanently waterproof at the seams but must be protected from ultraviolet light and mechanical damage. For this reason, when extended to the exterior of the building, it should be protected by metal counter flashings. These membranes are compatible with most types of sheathing membrane materials. They are compatible with most types of sheathing membrane systems.

End Dams

All flashings must have joints and terminations. It is at these interfaces where most flashing problems occur. When designing flashings that extend from the interior to the exterior of a cladding system, ensure that water cannot enter the wall at intersections in the flashing. The best way to achieve this is to have a good slope, watertight joints and adequate end dams. End dams are important because they stop water from flowing off the ends of the flashing. End dams should be watertight and have a sufficient height to prevent water leakage. When designing end dams, minimize the number of joints that require a sealant. Figure 7.3 shows one method of making end dams in metal flashing without cutting the flashing, thus making the joint permanently watertight. If heavy gauge extruded metal flashing is used, end dams should be both mechanically fastened and sealed.

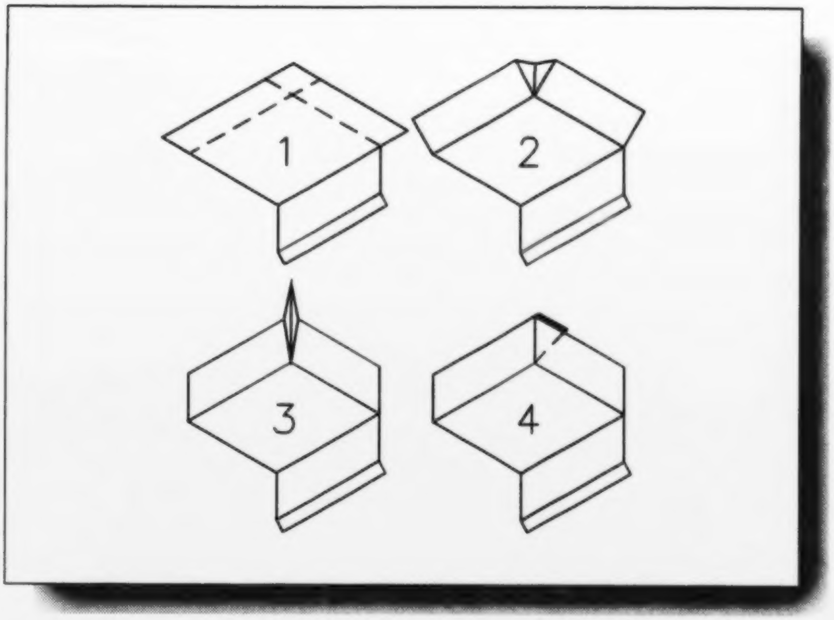

Figure 7.3: Flashing end dams

EAVESTROUGHS AND RAIN WATER LEADERS

Eavestroughs and rain water leaders can be an effective means of controlling water runoff (draining). They can reduce erosion around the perimeter of a building. Unfortunately, if improperly installed, they can also contribute to wall deterioration problems. Eavestroughs are typically constructed of prefinished aluminum, steel or polyvinyl chloride. As discussed in the section on flashings (page 7-8), the joints in metal flashing are virtually impossible to keep watertight unless large slopes are involved. Since high slopes are impractical on large runs of eavestrough, it is best to assume that joints and end caps will eventually leak and design the system to accommodate this. The following represents fundamental design principles for eavestroughs and rain water leaders.

- Always install the eavestrough with a positive slope towards the downspout. See *Architectural Sheet Metal Manual* for design tables.
- Select a large enough eavestrough to handle the expected roof runoff. The eavestrough size required will vary depending on the size of the roof, the location, and the slope. See *Architectural Sheet Metal Manual* for design tables.
- Never install an eavestrough termination tightly to the sheathing and then install cladding up to the gutter. If the gutter leaks it will drain into the wall cavity.
- Design roof slopes to avoid gutter returns into the building. It is much better to keep the gutters as far away from the cladding as possible. Set the overhang distance for the gutter and attempt to maintain this as the minimum distance between eavestrough and cladding when the roof line changes direction or terminates.
- Avoid using built-in gutters wherever possible. Water leakage is more detrimental when it occurs above the roof structure rather than at the outer edge of the roof overhang.

- Provide a flashing behind the eavestroughs to prevent water leakage at joints from contacting wall or fascia components.
- Drain rain water leaders away from the building or into a drainage system.
- Connect rain water leaders so that joints are lapped in the direction of flow to avoid leakage at connections.
- Take care when fastening eavestroughs and rain water leaders to the wall cladding. Use corrosion-resistant screws and seal fastener heads to prevent water infiltration in these locations.

CLADDING

The cladding types described in the following sections are the most commonly used in British Columbia's coastal climate zone. All of the cladding types can be durable if they are used in an appropriate assembly, for the installed exposure condition. Table 7.4 provides a comparison of different cladding materials based on the main physical properties of the cladding material only (not for the entire wall assembly). This table is intended to indicate some of the differences between cladding materials in order to assist in the selection of appropriate cladding for particular assemblies and exposure conditions.

WOOD AND HARDBOARD

Wood siding has been used extensively and successfully as a cladding material. In addition to the exposure and assembly discussed in previous chapters, the durability of exterior wood siding is also dependent on species, grade, joint method, and coatings. The properties of various joint methods and grading of various siding species and products can be found in the *Wood Reference Handbook*. Both for reasons of durability and aesthetics, it is important to consider the wood species. Table 7.5 compares common species used on the exterior of buildings.

In addition to species, the selected coating is also an important durability concern. Back priming of the wood can increase the durability of the product if it may be wet from behind. Figure 7.4 presents the relative performance of exterior wood coatings in service and Table 7.6 indicates their typical applications. Finally, assemblies and details that permit drying of the wood improve durability.

Hardboard is available in narrow boards usually installed horizontally, or larger panels installed vertically. Hardboard may be supplied unprimed, factory primed, or factory finished with paint or stain, and the surface is sometimes textured or embossed to resemble other cladding materials. Joints between cladding are designed to lap or lock. Joints between lengths of board siding are usually butt joints, with either sealant or a T-shaped trim covering the joint. Hardboard absorbs moisture easily, and it is important that it be protected by paint or water-repellent stain. Factory finishing is the most effective way for this to be done. Like solid wood, lapped hardboard siding provides a small cavity which is not drained unless round-headed nails are used to form a capillary vent at the interface between courses. Lock siding provides little space for drainage, and should always be installed on strapping.

Other cladding materials are also manufactured from wood-based products such as OSB.

Table 7.4: Comparison of Typical Cladding Types

Cladding Type[1]	**Resistance to Wind Driven Rain Exterior Cladding Layer Only**[1] (Exposed Fasteners/Concealed Fasteners) (1=best 4=worst)	**Drying Capability of Assembly Through Cladding**[2] (1=best 4=worst)	**Ability of Cladding to Absorb Water**[1] (1=low 4=high)	**Sensitivity of Cladding Material to Water Damage** (1=low 4=high)	**Maintenance Requirements** (1=low 4=high)	**Durability** (1=best 4=worst)	**Cost to Repair if Systemic Problems Are Encountered** (1=least cost 4=highest cost)	**Resistance to Physical Damage** (1=best 4=worst)
Wood–Shiplap	4/3	2	2	3	3	3	1	2
Wood–Shingles	3/2	1	2	3	3	3	1	2
Wood–Lap or Bevel Siding	3/2	1	2	3	3	3	1	2
Hardboard–Lap or Bevel Siding	3/2	2	3	4	4	4	1	3
Hardboard–Panel	3	3	3	4	4	4	1	3
Vinyl Siding	3	2	1	1	2	2	1	2
Stucco	2	3	4	2	2	2	3	2
Exterior Insulation and Finish System	2	3	3	3	2	2	2	4
Masonry	2	2	4	1	1	1	4	1
Fibre Cement Board–Lap Siding	3/2	1	2	2	2	2	1	2
Fibre Cement Board–Panel	3	3	2	2	2	2	1	2

[1] Comparisons of physical properties are based on the exterior cladding only, without cavities, sheathing membranes or other backup assemblies. This comparison is intended to be used for determining the level of corrosion resistance, durability, and protection that will be required by the components used in the backup wall assembly. This table should not be used to compare the as-built performance of a particular type of cladding, as this will vary significantly depending on both the assembly and components used.

[2] The drying capability of the assembly through the cladding is also dependent on the type of coatings applied to the cladding material and the design of the wall assembly. This comparison of drying capability is based on typical coatings and conventional face sealed or concealed barrier assemblies. Drying capability of assemblies through the cladding is far less critical in rainscreen assemblies due to the prevalence of other drying mechanisms and therefore is not presented here.

Table 7.5: Comparison of Typical Exterior Wood Cladding Species (Adapted from [illegible]

Species	Characteristics
Western red cedar	Reddish brown, highly resistant to decay, seasons well, resists warping and twisting, used for siding, decking, shingles and shakes.
Eastern white cedar	Blond to reddish brown, fine texture, light weight, highly resistant to decay, comparatively soft, used mainly for shingles.
Eastern white pine	Light colour, relatively soft. Durability is dependent on coating protection.
Jack pine/lodgepole pine	Light colour, medium hardness, often used as pressure treated wood. Durability is dependent on coating protection.
Eastern red pine	Light red colour, otherwise similar to jack pine and lodgepole pine. Durability is dependent on coating protection.
Douglas fir	Even grain, weathers well, hard durable softwood. Durability is dependent on coating protection.
Spruce	Off-white to pale yellow, medium strength, low decay resistance, not easily pressure treated. Durability is highly dependent on coatings and exposure protection.
Plywood	Medium density overlaid plywood can be used in exterior applications protected with an exterior coating of resin and fibres. Low decay resistance, not easily pressure treated. Durability is highly dependent on coatings and exposure protection.
Hardboard	Highly compacted wood fibre product that is sealed with a resin coating. Low decay resistance, not easily pressure treated. Durability is highly dependent on coatings and exposure protection.

VINYL

Vinyl siding is produced in different shapes and patterns to simulate wood bevel siding, cedar shakes, brick and vertical board and batten. It is designed to be fastened along the top edge and interlocked along the bottom edge so that fasteners can be concealed. Vinyl siding must have vent/drain holes in the bottom of the profile. Vinyl siding performs very well in the main field of the wall. However, it is difficult to make terminations and intersections watertight because of vinyl's high thermal expansion and the large numbers of joints. Also the relatively thin nature of the cladding makes proper sealant profiles for movement joints difficult to install. Typically, vinyl has been

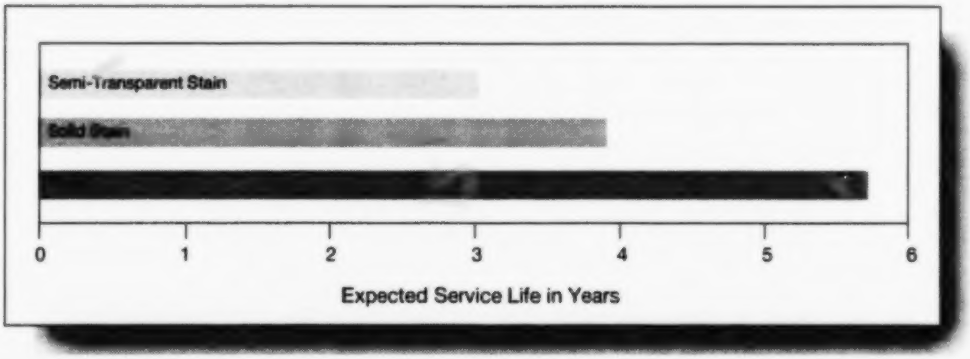

Figure 7.4: Relative durability of exterior coatings

Table 7.6: Durability of Typical Exterior Coating Applications (Adapted from [illegible]

Type of Coating	Application	Primer	Topcoat	Notes
Paint (latex)	Walls and vertical surfaces	1 coat alkyd or latex primer	2 coats latex	
	Horizontal surfaces		2 coats alkyd enamel	
Stain (solid hide)	Vertical surfaces only	1 coat stain (alkyd or latex)	1 coat stain (alkyd or latex)	
Stain (semi-transparent)	All surfaces		1 coat stain (alkyd)	

finished at intersections by installing a custom-made trim piece to shed water. Care must be taken to ensure that trim flashings at penetrations will prevent the ingress of water behind the cladding. Starter strips at the base of the wall must not impede drainage or divert water behind the cladding at terminations. The thermal expansion and contraction of vinyl can vary between 6 and 12 mm in a standard 4 m (12'-13') length. This thermal expansion must be accommodated by the fasteners, or the siding will buckle. It is important to remember to place nails in the centre of the nail slots. Prevent over-hammering of the nails so that the siding is free to move laterally.

Installation of vinyl siding over furring strips in a rainscreen wall introduces additional design issues which include the following:

- The impact resistance may be reduced because of the lack of continuous backing.
- Interlocking seams between vinyl profiles may lose integrity due to the larger deflections between supports.
- The wind load resistance capacity may be reduced.

STUCCO

As with wall assemblies incorporating other popular cladding types, there have been significant problems with stucco clad assemblies. When used in the appropriate exposure condition as discussed in the Chapter 5, stucco has the ability to be a durable cladding material. Stucco is typically built up in three layers to a thickness of 22 mm (7/8"), over a metal lath that is fastened to the sheathing or strapping. The metal lath limits the size of cracks in the stucco and holds the stucco against the sheathing or strapping. The first and second coats are called scratch and brown respectively and the final coat or third layer is referred to as the finish coat. There are numerous mix designs for stucco incorporating different cement and aggregate combinations or acrylic modifiers as well as coatings that are intended to increase water resistance and flexibility. The *Specifications and Standards Manual* and the *Stucco Resource Guide* contain detailed information regarding mix design, control joint spacing and installation recommendations.

Recently there has been a shift towards 'rainscreen' stucco assemblies that incorporate a cavity behind the stucco veneer. These systems are discussed in detail in Chapter 5. These rainscreen assemblies create new design parameters that need to be considered. These additional parameters include the following:

- Drying from both sides: In order for stucco to fully cure it must be kept moist throughout the curing period. When a cavity is incorporated into the assembly, water will evaporate from both sides of the stucco and additional methods of moist curing may be required to prevent cracking.
- The installation of a drained cavity recognizes that water will be present behind the stucco. Additional corrosion protection may be required for fasteners, lath and accessories exposed to this water.
- The inclusion of a cavity results in a thicker overall wall assembly. This may cause alignment problems with adjacent cladding assemblies such as nail-on flange windows.
- Stucco applied over strapping strips does not have continuous support from the sheathing. An appropriate lath or other backing must be used to span between the strapping strips and provide support for the stucco to maintain a relatively uniform thickness.

Examples of excessive cracking have been reported with cavity stucco systems. With all stucco cladding it is important to locate control joints where there is a potential for differential movement, and in areas that exceed 4572 mm (15') in length. The control joints should extend through the lath and other accessories to eliminate restraint at panel edges. Cracking can also be limited if the control joint extends through the lath and other accessories to eliminate restraint at the panel edges. Large T or L shaped stucco panels should be avoided by separating them into smaller rectangular panels.

EXTERIOR INSULATION AND FINISH SYSTEM (EIFS)

Exterior insulation and finish system claddings generally consist of a layer of expanded polystyrene insulation (EPS) covered with a polymer-based lamina on the exterior and sides. The lamina consists of 2 layers of base coat sandwiching a glass fibre reinforcing mesh and covered with an acrylic finish coat. The total thickness of the lamina is usually between 1.5 mm (1/16") and 3 mm (1/8"). A traditional face-seal exterior insulation and finish cladding relies on an adhesive bond to the sheathing. If water penetrates the cladding and deteriorates the sheathing, the cladding will detach from the building. There have been several examples of moisture problems occurring on buildings with EIFS installed as a face-sealed assembly. As a result, there has been a trend towards drained cavity or rainscreen EIFS. These typically involve both coating of the substrate with a moisture-resistant base coat and creating vertical drainage channels between the sheathing and the expanded polystyrene insulation. These assemblies are proprietary and differ between manufacturers. Most of these systems have been developed in the past few years and do not have an established track record. The EIFS assembly presented in Chapter 5 is a mechanically attached rainscreen assembly.

Very little has been published in terms of design guidelines and master specifications for exterior insulation and finish system claddings. *Exterior Insulation and Finish System Design Handbook* and *Exterior Insulation and Finish Systems: Current Practices and Future Considerations* provide detailed information on the design and specification of face-sealed exterior insulation and finish systems. Comprehensive guidelines for the rainscreen exterior insulation and finish system assemblies have not yet been established; consult individual manufacturers for specific installation guidelines.

MASONRY VENEER

Traditionally, masonry veneer walls have been installed with a drained and vented cavity behind the masonry. For this reason, they perform very well in their resistance to wind-driven rain and in their drying capability. When masonry veneer is used in wood-frame construction, the masonry is set on a ledge in the foundation wall. Before the masonry is installed, a base flashing is installed on the foundation wall ledge and up the sheathing 150 mm to divert water that infiltrates behind the masonry to the exterior (Figure 7.5).

The base flashing must be constructed of a material that is durable and can be made permanently watertight at joints.

Weep holes installed above the base flashing provide a venting and drainage function. They should be placed about 600 mm apart in the bottom course of the veneer. Weepholes can be installed by omitting the mortar from the vertical joints, however, it is good practice to install a plastic rain deflector in the weep holes to keep them free of mortar and to reduce the amount of water that enters the weepholes.

The ledge in the foundation wall takes the vertical weight of the brickwork. The masonry units are also supported laterally with brick ties attached to the exterior sheathing. Brick ties are usually spaced at 600 mm apart horizontally and 400 mm vertically, or 400 mm horizontally and 600 mm vertically, depending on the stud spacing. Modern, two-piece adjustable ties are recommended rather than flat strip ties, and can provide design spacing up to 800 mm apart horizontally and 600 mm vertically.

Additional design issues that are influenced by the local climate include the following:

- **Connectors:** In this region *Connectors for Masonry*, CSA A370-94, recommends that brick ties and fasteners be hot dipped galvanized for buildings up to 11 meters in height and constructed of stainless steel for buildings above this height.
- **Jointed Window Sills:** All masonry sills must be well sloped to shed water. A continuous precast sill or a brick masonry sill covered with metal flashing at window sills and other penetrations is recommended to reduce water infiltration behind the masonry. Jointed sills constructed of exposed brick and mortar should not be used unless a watertight flashing is installed under the sill. However, even with a watertight flashing, the high volume of water that will penetrate throughout the mortar joints in the sill will result in staining and mildew growth as well as accelerated deterioration of mortar.
- **Frame Shrinkage:** Because the masonry is supported entirely on the foundation wall, the shrinkage of the wood framing will occur independently of the masonry which may experience virtually no shrinkage (clay brick may experience moisture-related expansion). As frame shrinkage occurs, windows and other penetrations through the masonry will move downwards with the wood structure. Joints at windowsills and heads must be designed to accommodate this movement, which can be as high as 20 mm per floor. An example of this phenomena is presented in Example 4, Chapter 2 (page 2-13).
- **Mortar:** A high lime based mortar such as type S or N cement-lime mortar should be used.
- **Masonry Joints:** Concave mortar joints are recommended for use in this region. Raked joints are not as effective at deflecting water and will allow more infiltration into the masonry veneer.

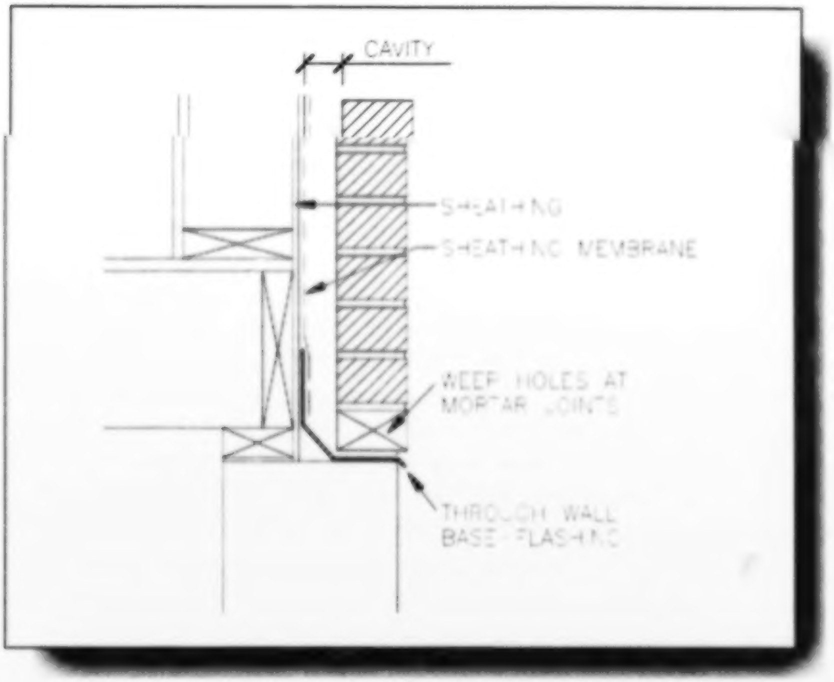

Figure 7.5: Masonry base flashing

- **Masonry Units:** Units of moderate absorption should be used. Additional attention to details should be given if architectural units of high water absorption characteristics are selected. Clay brick should meet *Grade SW (Severe Weathering)*, CSA A82.1-84.
- **Corbels:** Masonry walls should be designed to minimize corbels unless a metal flashing is installed to divert the water over the brick row that is set out of the plane of the wall.
- **Flashing:** Flashing must extend to the exterior face of the masonry above all windows, doors and wall bases. It is recommended that flashing extend past the cladding to form a drip edge.
- **Control Joints:** Provide an adequate number and size of control joints to minimize cracking and possible rain penetration.
- **Workmanship:** Complete and full mortar joints, the bond between mortar and masonry, unobstructed weep holes and clear cavities are important workmanship issues that will affect the performance of the assembly.
- **Coatings:** The application of a water-repellant coating is often used in this region. The coating must be highly vapour permeable to allow drying of the masonry. The coating should produce a surface that is resistant to water penetration after a prolonged exposure to weathering. Comparisons of test results for *Standard Test Method for Water Penetration and Leakage Through Masonry*, ASTM 514 (1996)e1, and a weatherometer test are useful for comparing water resistance and weathering characteristics respectively. The selection of the coating type as well as the surface preparation and installation procedures must also be carefully considered. Consult *A Guide to Rain Resistant Masonry Construction for the British Columbia Coastal Climate* for more information on masonry coatings.

FIBRE CEMENT BOARDS

Fibre cement panels are relatively new in Canada, and therefore there is very little design, specification and reference material available for these products.

Fibre cement boards are manufactured by fully encapsulating wood fibres in a sand and cement binder. Fibre cement boards can be very durable and resistant to water related deterioration. In addition, they can be produced to simulate different wood textures and patterns. The dimensional stability under varying moisture contents and temperatures, along with the thickness of the product, allows durable movement joints to be constructed with sealants at intersections. Consult manufacturer's literature and the *Registry of Product Evaluations* for additional recommendations and installation techniques.

WINDOWS AND SLIDING DOORS

Windows represent one of the most complex components of the building envelope. Integration of the window into the adjacent wall assemblies is an important interface and is discussed in detail in the previous chapters. This section deals only with the window and glazing units separate from the adjacent wall assemblies.

A detailed explanation of window and glazing issues is provided in *Glazing Systems Specifications Manual*. For the purposes of this Guide, we have summarized this information and provided minimum recommendations for British Columbia's coastal climate. *Windows*, CAN/CSA A440-M90, is the national standard that covers window design, manufacturing and installation. It requires that all windows be classified according to airtightness, watertightness, and wind load resistance. For buildings that must conform to Part 9 of the *National Building Code of Canada* and that are covered by this Guide, Table 7.7 indicates the performance levels that are recommended for windows and sliding doors in most locations in the coastal climate zone including Vancouver and Victoria.

Table 7.7: Recommended Minimum Window Performance Levels for the Coastal Climate Zone

Requirements	Minimum Level
Air leakage	A2, 1.65 $m^3/h/m$ (windows and doors)
Water leakage	B3, 250 Pa (windows and doors)
Wind load resistance	C3 (windows and doors)
Condensation resistance	Temperature index I48 (windows)
Minimum U factor for window frame and glazing	3.75 $W/m^2/°C$

Areas with high exposure such as the west coast of Vancouver Island and the Queen Charlotte Islands as well as other areas that have high wind-driven rain indexes must be designed with higher water penetration resistance ratings. Recommended performance for these areas is presented in Table 7.8.

Designers of larger buildings not covered by Part 9 of the *National Building Code of Canada* should use CAN/CSA A440.1-M90, *User Selection Guide to CSA Standard CAN/CSA A440-M90, Windows* to select appropriate levels of performance for the specific building and location.

Table 7.8: Recommended Minimum Window Performance [illegible] High Exposure

Requirements	Minimum Level
Air leakage	A2, 1.65 $m^3/h/m$ (windows and doors)
Water leakage	B6, 600 Pa (windows and doors)
Wind load resistance	C4 (windows and doors)
Condensation resistance	Temperature index I48 (windows)
Minimum U factor for window frame and glazing	3.75 $W/m^2/°C$

The water leakage parameters are selected using predicted Driving Rain Wind Pressure, which is estimated to be exceeded once every 10 years on buildings. Since the selection and testing of windows for water leakage is performed to levels that will likely be seen by the building during its life, it is important to select a window that will be able to maintain original levels of watertightness for its expected design life. The most effective method of accomplishing this is to incorporate rainscreen design principles into the design of the window frame and glazing. In addition, it is important to use sealants and joint profiles within the window assembly that will have durability equal to that of the window framing and glazing. Many aluminum window systems utilize plasto-elastic sealants to seal butt and mitered joints in aluminum frames that are often designed to be periodically submerged in water. These sealants are critical to the performance of the system, but can be far less durable than the window frames and the insulating glass units.

The three major window frame types used in wood-frame construction are wood, vinyl and aluminum, and are discussed below.

WOOD WINDOWS

Wood windows are not as common as either vinyl or aluminum in coastal British Columbia. Painted wood windows, especially their sealants and exterior finish, require more maintenance than vinyl or aluminum when exposed to repeated wettings. To reduce the amount of maintenance, wood windows should be installed with adequate overhang protection to minimize contact with water. To further reduce maintenance requirements, many wood window manufacturers also produce windows with aluminum or vinyl cladding on the exterior. These assemblies are generally more durable, and, depending on the design of the window assembly, they can usually be installed in more exposed conditions. Because of the popularity of vinyl and aluminum windows and the many different wood-frame designs available that incorporate various combinations of materials, wood windows have not been presented in the assemblies section. However, the design of wood windows can be classified, in the same manner as aluminum and vinyl windows, into the three categories of face-sealed, concealed barrier and rainscreen, and wood windows can be used in an appropriate exposure condition, as outlined in Chapter 5.

ALUMINUM WINDOWS

Aluminum is inherently durable and requires low maintenance. As well, the ease of fabrication and low cost are key factors in the popularity of aluminum windows. Aluminum windows can also be easily reinforced and adapted to accommodate larger glazing units. Problems with aluminum windows usually occur as a result of poor frame design or a failure of the internal sealant materials that seal metal frame sections together at joints. Aluminum is also a very efficient conductor of heat. To reduce the heat flow through the frames, manufacturers install a thermal break between interior and exterior sections of window to separate the cold and the warm side of the frame. Aluminum is also susceptible to corrosion when exposed to alkalis released from concrete, stucco, plaster and masonry either by direct contact or by water washing over the cement-based surface and then onto the aluminum frames. See Chapter 5 for a discussion of the main types of aluminum window assemblies.

VINYL WINDOWS

Vinyl windows have become increasingly popular because of the low levels of maintenance required and advances made in the framing systems. Vinyl windows can be welded together at joints in the framing, reducing the durability problems associated with the sealants at these critical areas. Another advantage of vinyl windows for wood-frame construction is the increase in thermal performance over aluminum frames.

Vinyl windows should be designed in accordance with the rainscreen principle to shed water at the exterior and drain water which infiltrates into the framing system back to the exterior. See Chapter 5 for a discussion of the main types of vinyl window assemblies that are currently available. One common misconception is that the ability to fully weld the corners will prevent water infiltration through the frames. Metal screws are often used to fasten mullions to frames and it is still possible for leakage to occur at these fasteners if they are located at the sill and are not sealed. Vinyl window frames that are joined with fusion-welded joints may be considered watertight and airtight, provided that all joints are fusion-welded and no mechanical fasteners penetrate to the exterior of the frame.

QUALITY ASSURANCE

The current standard *Windows*, CAN/CSA A440, requires that the manufacturer have only one window of each type tested for the performance requirements discussed above. There is no requirement in the standard for a minimum level of quality control in the manufacturing process, nor is there any required follow-up random testing of windows. Finally, there is no requirement in the current standard that any of the windows installed in the building meet the performance requirements. Some window manufacturers exceed these minimum criteria by performing random testing on their products and by initiating quality assurance programs such as ISO 9000. However, many others have not yet advanced to this stage.

Field testing of the completed installation remains the only sure way to test if the non-structural performance criteria have been met. Water penetration resistance tests can be performed in the field in accordance with ASTM E 1105, *Field Determination of Water Penetration of Installed Exterior Curtain Walls and Doors, by Uniform or Cyclic Static Air Pressure Difference, by using AAMA 502-90, Voluntary Specification for Field Testing of Windows Test Method B*. This field test incorporates both the windows and the interface with the adjacent cladding. Field-testing should be performed on large projects to assess the performance of the windows and sliding doors prior to completing construction, allowing time for repairs to be implemented. If the leakage through the test window is severe, or if it is difficult to repair, additional testing should be performed in order to confirm the effectiveness of the remedial repairs on the windows that have already been installed. Table 7.9 outlines the recommended minimum test frequency for various sized projects.

Table 7.9: Number of Recommended Field Tests

Number of Windows	Prior to 5 per cent Installed	At 50 per cent Installed	At 100 per cent Installed
0-25	0	0	0
25-100	1	0	0
100-200	2*	1	0
>200	3*	2	2

*At least one exposed sliding door if present

INSULATED GLAZING UNITS

Insulated glass units are made up of 2 or more lites of glass separated by a spacer and sealed with a high performance sealant around the perimeter as shown in Figure 7.6. One of the best types of insulated glass units from a longevity standpoint incorporates a dual perimeter seal consisting of an interior polyisobutylene sealant and an exterior silicone or polysulphide sealant installed with a hollow stainless steel or aluminum spacer bar filled with desiccant.

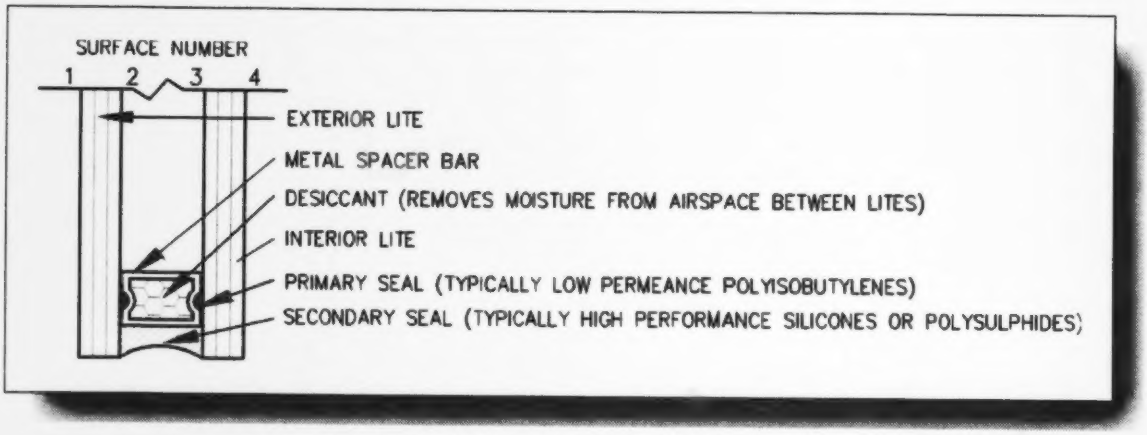
SURFACE NUMBER
1
2
3
4
EXTERIOR LITE
METAL SPACER BAR
DESICCANT (REMOVES MOISTURE FROM AIRSPACE BETWEEN LITES)
INTERIOR LITE
PRIMARY SEAL (TYPICALLY LOW PERMEANCE POLYISOBUTYLENES)
SECONDARY SEAL (TYPICALLY HIGH PERFORMANCE SILICONES OR POLYSULPHIDES)

Figure 7.6: Typical insulated glazing unit

Dual seal construction makes it possible to utilize the best properties of each sealant (see Table 7.11, page 7-31). The primary seal of polyisobutylene and the aluminum spacer bar act as the vapour barrier minimizing ingress of water vapour. The secondary seal of silicone holds the lites of glass together and prevents water from contacting and deteriorating the vapour barriers. Polysulphides are also used successfully as secondary sealants. This type of glazing unit (with clear glass) represents the standard that should be used to compare other insulated glass edge seal systems.

Recently, with the focus on energy efficiency, warm edge technology (WET) insulated glass units have been gaining popularity, especially in colder climates where energy efficiency and condensation resistance are higher priorities. In general, WET units remove all or part of the metal spacer bar and replace it with more thermally efficient materials. While this results in an increase in energy performance, it can reduce the longevity of the glazing unit if the materials used do not provide the same performance levels as the standard insulated glass unit discussed above. If WET units are contemplated, compare the selection of sealants with *Insulating Glass Units*, CAN/CGSB 12.8M97, and with Table 7.11 (page 7-31) to ensure that a similar level of protection is maintained. For example, if the WET unit replaces the aluminum spacer bar with a softer material, ensure that there is a continuous vapour barrier, sufficient support for the glass when the unit is compressed, and a high performance sealant to hold the glass together and protect the vapour barrier.

Other factors to consider when selecting glazing units are Low E coatings and argon gas filled units. Both Low E coatings and argon gas generally increase the RSI value of the glazing, making it significantly more energy efficient. There are no disadvantages to using Low E coatings or argon other than a marginal initial cost increase, provided that adequate insulated glass units are used.

SKYLIGHTS

There are no voluntary industry standards governing the performance of sloped glazing systems. Nor are there appropriate national standards that cover all skylights equivalent to the national standard for windows. CAN/CGSB 63.14, *Skylights–Plastic*, covers only factory glazed unit skylights and recommends minimum performance requirements of A1, maximum air leakage rate of 2.79 m^3/h/m for airtightness, and B1, static differential pressure of 137 Pa for watertightness. In the coastal climate of British Columbia, these performance requirements should be increased to a minimum of that recommended for windows in Table 7.7. Skylights are the least regulated of the exterior glazing systems and designers and owners should not assume that a particular skylight or sloped glazing application will be designed and installed to the same performance levels as adjoining windows and curtain walls.

Not all types of skylight systems offer equivalent design and performance features. Even skylight systems which appear to be identical may differ radically in their features, and in their suitability for enclosed humid, heated spaces. The resistance to water infiltration is usually the highest priority with skylights. As a result, both air leakage and condensation resistance are often ignored or sacrificed in order to accomplish the primary objective. Many skylight systems used in British Columbia do not incorporate an air barrier tie-in with the building or a thermal break to reduce condensation. In addition, subtle internal differences can produce a successful installation or a problematic one. Evaluating the performance of different skylight systems requires a detailed understanding of how sections are sealed, joined, glazed, and connected to the building air barrier. Refer to *Glazing Systems Specifications Manual* for more detailed information on the comparison, selection, design and specification of skylight systems.

Sloped glazing systems are typically sloped a minimum of 15 degrees to a maximum of 85 degrees from the horizontal. Glazing systems intended for vertical installation are not suitable in sloped applications because external seals are not usually sufficient to deflect water flowing along the surface of the glass and internal drainage systems are not designed to carry the water that infiltrates into the frames to the exterior at the base of the skylight. Three categories of skylights are commonly used in the types of buildings discussed in this Guide. They are: factory glazed unit skylights, T-bar, and pressure cap systems. Table 7.10 identifies the design features available for different types of skylight products.

Table 7.10: Comparison of Skylight Design Features

Design Feature	Factory Glazed Unit	T-Bar – Concealed Barrier	Pressure Cap – Concealed Barrier	Pressure Cap – Drained	Pressure Cap – Pressure Equalized Rainscreen
Single Glazed	✔	✔	✔		
Double Glazing, 4-sided support	✔		✔	✔	✔
Resist wind uplift	✔		✔	✔	✔
Control of water leakage under differential pressure	✔			✔	✔
Air leakage control					✔
Suitable for use in high humidity environments					✔
Condensation control –hold for re-evaporation	✔				✔
Condensation control –drain to exterior	✔		✔	✔	

For public safety, all overhead glazing systems incorporating single glass or insulated glass units must use laminated or wired safety glass on the most interior lite of glass. In the event of breakage, this safety glass will prevent large individual pieces of glass from falling out of the skylight onto the occupants below.

Common problems reported with skylight systems include:

- Reports of water leakage that are in fact condensation-related moisture due to poor air seals or poor thermal breaks in skylight assembly.
- Potential for overheating due to the large heat gain potential of the glazing assembly.
- Large thermal movements in acrylic skylight domes causing damage to sealants and water leaks. Joints in acrylic assemblies must be carefully designed to accommodate large thermal movements.

FACTORY GLAZED UNIT SKYLIGHTS (GLASS OR PLASTIC GLAZING)

Factory glazed unit skylights are very common in residential construction. They are usually double glazed, with two sheets of moulded plastic (acrylic or polycarbonate domes) or with an insulating glass unit. In all systems, the glazing is retained against an aluminum or polyvinyl chloride base frame by an aluminum cap. The base frame is designed to collect condensation and rain water that seeps past the exterior cap, and drain it safely to the exterior. Typically, these skylights should be installed on a curb that will vary in height depending on the slope of the roof as follows:

- roof slope 3:12 or less, 300 mm
- 4:12, 150 mm
- greater than 5:12, 100 mm

Detailed installation details for acrylic domed and unitized glass skylights are contained in *Best Practice Guide: Flashings* and are summarized in Figure 7.7.

These skylights are the least expensive and easiest type of skylight to install, but care is required to flash the curb properly and to orient the skylight correctly to drain water.

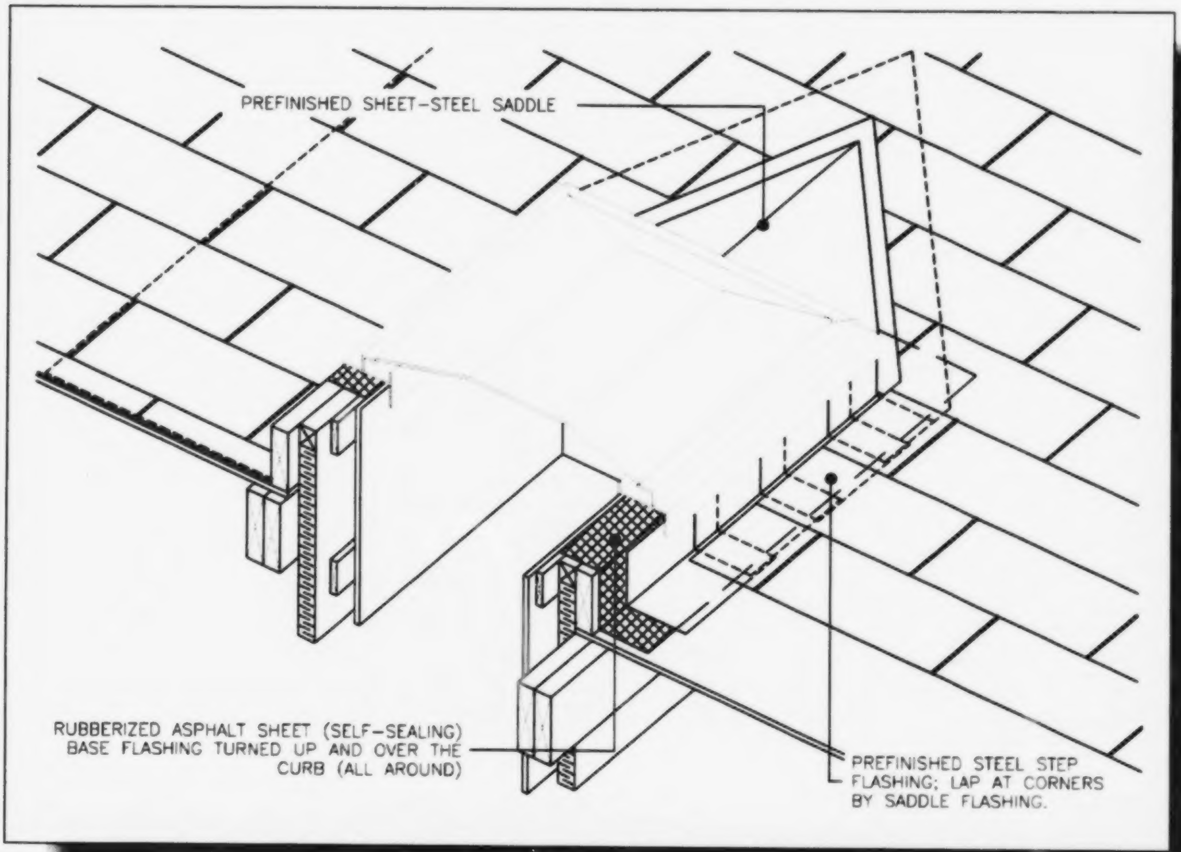
PREFINISHED SHEET-STEEL SADDLE
RUBBERIZED ASPHALT SHEET (SELF-SEALING) BASE FLASHING TURNED UP AND OVER THE CURB (ALL AROUND)
PREFINISHED STEEL STEP FLASHING; LAP AT CORNERS BY SADDLE FLASHING.

Figure 7.7: Typical unit skylight installation

Properly installed, unit skylights can provide years of service. When a larger skylight area is required, several independent skylights may be used, but each must rest on an individually flashed curb. Unit skylights are not designed to be coupled together to form larger skylights. Attempts to group unit skylights into large arrays or complicated shapes have not generally performed well. Larger, multiple skylights should be built from pressure cap systems that are designed for multiple lite glazing.

T-BAR SYSTEMS

The most common type of residential skylight is the low cost, low performance T-bar system. The mullions are shaped like inverted T sections to support the glass (Figure 7.8). The flange of the bar is profiled so it collects water and diverts it to the base of the skylight. T-bar skylights have numerous drawbacks and limitations when used over heated living space, including the following:

- The basic system does not provide an air seal at the sill and there is no provision to attach building air, vapour or water shedding membranes to the frame on any side. As a result, T-bar skylights typically require a minimum slope of 25 per cent.
- There is no effective air seal between the perimeter of the insulated glass unit and the skylight frame. This results in a high rate of air leakage through the skylight. When installed over heated space, condensation can occur on the hermetically sealed glazing units. As a result, most sealed unit manufacturers will not warranty their units if installed in T-bar skylights over a high-humidity space. T-bar skylights should not be used in high humidity buildings or areas such as swimming pools or hot tubs.
- Typical T-bar systems provide only two-sided support for the glazing units. This violates the Insulated Glass Manufacturers Association's recommendations for acceptable support for snow and wind loads outlined in *Glazing Recommendations for Sealed Insulating Glass Units*. As a result, many sealed unit manufacturers will not warranty sealed units used in T-bar systems.
- The exterior snap-on glazing beads used to retain the glass in most T-bar systems are unreliable in their ability to retain the glass when subjected to strong negative wind loads.
- T-bar skylights are inherently weak and do not span average or large distances without significant structural reinforcement.
- There is no method of reliably joining glazing units in the horizontal direction with a purlin. T-bar skylights incorporating more than one glazing unit between two rafters are not recommended.

The standard T-bar product is not recommended for overhead sloped glazing over heated spaces. This product should only be used for exterior single glazed skylights and canopies.

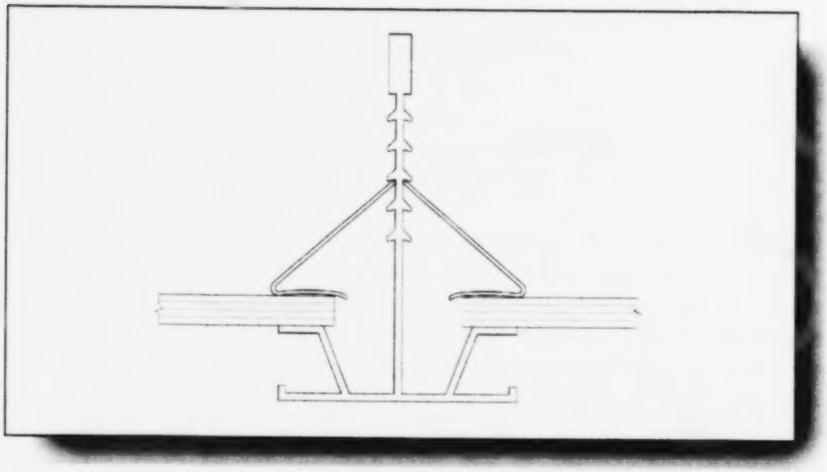

Figure 7.8: Typical T-bar skylight

PRESSURE CAP SYSTEMS

Pressure cap systems can range in price and performance from low-priced residential skylights to high performance commercial products intended to enclose large areas. The performance of these systems can vary greatly depending on the design of the system and on the quality of the perimeter flashings and installation. Pressure cap systems can also be bent in a radius to form barrel skylights, however, care must be taken to eliminate rafter joints and to ensure that the glass at the top of the barrel is adequately sloped. Pressure cap systems can be divided into three categories: concealed barrier, drained systems, and pressure equalized rainscreen.

In concealed barrier systems, the exterior glazing stops are not watertight and internal gutters that divert water to the exterior are open to the interior. The lack of a watertight seal on the exterior, combined with the lack of an air seal, make these systems vulnerable to water leakage under differential pressures.

Drained systems incorporate a relatively watertight face seal to reduce the volume of water entering the skylight drainage system and to provide an air seal across the exterior face of the glass. In both concealed barrier and drained systems, water is drained through open drainage channels to the base of the skylight where it exits the building. In order to do this, the drainage channels penetrate the air barrier and allow uncontrolled air leakage at the base of the skylight.

Figure 7.9 shows an example of a pressure equalized rainscreen framing system. Pressure equalized rainscreen systems incorporate an air barrier on the interior of the system attached to the inner glazing lite. In this case, the network of internal drainage gutters is sealed off from the building interior in the plane of the inside surface of the glass. The drainage gutters are vented to allow pressure equalization across the exterior seals. Water that migrates into the drainage gutter system is expelled to the exterior at the base of the skylight. The interior side air barrier in a pressure equalized rainscreen system accomplishes three vital functions. It reduces air leakage through the skylight for greater comfort and energy efficiency. It reduces the incidence of water leakage into the internal gutters due to differential pressures between the inside and the outside of the skylight. The air barrier also protects the edge of the insulated glass unit from air leakage related condensation, making pressure equalized rainscreen systems the only type of skylight suitable for enclosing high humidity areas such as pools and hot tubs. Pressure equalized rainscreen systems have a good track record of performance and many manufacturers offer systems that have been fully tested.

DOORS

Traditionally, residential entrance doors have been located under entrance canopies or overhangs to protect the entry from direct exposure to wind-driven rain. In these applications, the door and frame are kept relatively dry and the selection of weather-stripping and thresholds is based primarily on airtightness and aesthetics. As a result, residential door technology has not generally advanced to the water resistance levels of sliding patio doors and windows.

When entrance doors are located in higher exposure areas where overhang protection is reduced, a storm door should be used to deflect wind-driven rain and protect the wood door and frame. This method of door protection is

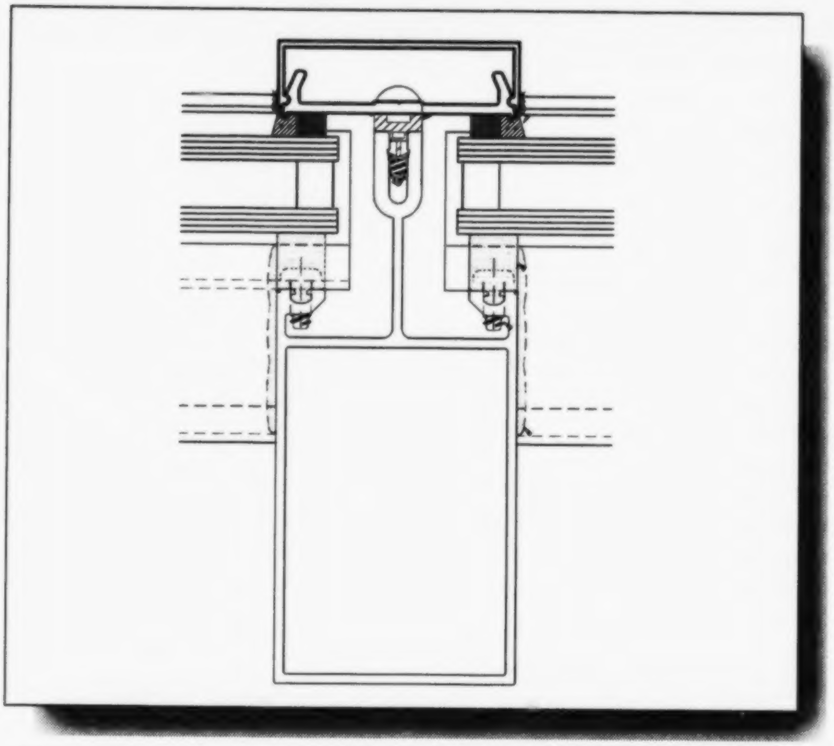

Figure 7.9: Pressure equalized rainscreen skylight

successful because it utilizes the rainscreen principle. The interior door is outfitted with an airtight interior weather-stripping. At the base of the door, a sloped metal threshold is installed with an upturn to prevent water from blowing under the door and to deflect water to the exterior and protect the framing. Finally, a metal and glass exterior storm door is installed with venting to allow pressure equalization and flashings to deflect water to the exterior. This is the recommended method of weatherproofing exterior doors that have a higher exposure to wind-driven rain. For areas with extreme exposure, both a storm door and overhang protection should be provided.

In some situations, the installation of a storm door or overhang protection cannot be provided. These situations should be avoided as much as possible. However, if an exterior door is to be directly exposed to the elements it must be at least as resistant to air leakage and wind-driven rain as the windows. It is possible to test doors in accordance with the test parameters outlined in *Windows*, CAN/CSA-A440, for windows and sliding doors. If entrance doors are to be used in exposed situations, test reports verifying air and water leakage rates of A2 and B3 should be obtained from the door manufacturer, or field testing as outlined in Chapter 7 should be expanded to include at least one randomly chosen entrance door.

SEALANTS

Sealants used in building construction are classified into the following chemical types:

- high-performance neutral cure silicone sealants
- polyurethanes
- polysulphide sealants

- thermo-plastic elastomeric sealants
- mildew-resistant silicones
- acetoxy silicones
- acrylics
- acrylic latex one part
- acoustical
- butyl
- oil-based

Many of these sealant types provide similar performance and they are often grouped into categories which recognize this. For the purpose of this discussion, the relative size and frequency of movement the material successfully can withstand is used as the basis for comparison. The ultimate and cyclical movement capacity is one of the most important factors when selecting an exterior weathering sealant. Other factors that must be carefully considered when selecting and using a sealant are ultraviolet light resistance, compatibility with the substrates, expected life, and proper joint design. These factors are discussed in general terms in Table 7.11 and illustrated in Chapter 6.

LOW MOVEMENT SEALANTS

Low movement or plastic sealants will withstand only slight and infrequent joint movement as they do not extend or compress elastically. Their durability is often reduced by exposure to sunlight and extremes of heat and cold. These sealants include bituminous rubber, oleoresinous and butyl rubber. Applications of this type of caulking should be restricted to joints that are not subjected to constant movement cycles or large deflections and are relatively protected from exterior weather. The service life of this group will vary with the type of caulking and the exposure condition, however, they generally range from 2 to 5 years when used in exposed exterior applications.

Sealants in this category are often ideally suited for sealing interior non-moving joints within the wall assembly. In these applications, many sealants in this category have the ability to function adequately over the life of the wall assembly.

MEDIUM MOVEMENT SEALANTS

Medium movement sealants can be grouped into two categories: plasto-elastic and elasto-plastic. Plasto-elastic sealants include acrylic latex, acrylic solvent and butyl and thermoplastic elastomerics (kreytons). These sealants can withstand more movement than plastic caulking but elastic movements are usually below 12 per cent of the joint width. Elasto-plastic caulking, such as one- or two-part polysulphide, have the advantage of some stress relaxation when deformed. For this reason, they perform adequately in slow moving joints such as masonry control joints. Recommended maximum movements are usually below 25 per cent of the joint width. When installed properly generally life expectancies range from 5-15 years for plasto-elastic sealants to 10-20 years for elasto-plastic sealants.

HIGH MOVEMENT SEALANTS

High movement sealants or elastic sealants include materials such as one- and two-part polyurethanes as well as acetoxy and neutral cure silicones. These types of sealants recover completely after most deformations and are suitable for large or fast moving joints such as those between metals and

Table 7.11: Typical Sealant Usage Guide

Joint Function	Best Performance	Moderate Performance	Not Recommended
Perimeter of exterior openings and windows at joints with exterior facade of building (typical cementitious and metal-based materials and associated coatings such as stucco, EIFS, masonry, most aluminum and steel coating systems)	1, 2	3, 4	5-11
Perimeter of exterior openings and windows at joints with exterior facade of building (typical vinyl-based and coated materials such as siding, windows and some stucco trims)	1	2, 3, 4,	5-11
Expansion and control joints in exterior surfaces	1, 2	3, 4	5-11
Joints in prefininshed metal flashings exposed to the exterior	1, 2	3, 4	4-11
Joints in metal gutters exposed to the exterior	1, 4	6	2, 4, 5, 7-11
Interior joint around the perimeter of window to wall flashing as detailed on drawings		4, 10	1-3, 5-9, 11
Interior control and expansion joints in floor surfaces	1, 2, 3		4-11
Perimeter of bath fixtures (e.g. sinks, tubs, urinals, stools, waterclosets, basins, vanities)	5		1-4, 6-11
Exposed interior control joints in drywall	7, 8		1-6, 9-11
Perimeter of glass surfaces	1	6	2-5, 7-11
Sealing laps in polyethylene vapour retarder or drywall for sound attenuation or air seal	9	10	1-8, 11
Air barrier seal between joints in exterior sheathing	1, 2	3, 4	5-11

KEY:

1 High performance neutral cure silicones
2 Polyurethanes
3 Polysulfides
4 Thermoplastic elastomerics (kreytons)
5 Mildew resistant silicones
6 Acetoxy silicones
7 Acrylics
8 Acrylic latex one part
9 Acoustical
10 Butyl
11 Oil-based

other materials having high thermal expansion coefficients. Adhesion is good for a wide range of materials. These sealants typically have life expectancies ranging from 10 to 25 years.

PROPER JOINT DESIGN

Sealants installed into a joint must be able to allow the substrate to expand and contract without cracking (cohesive failure) or pulling away from the substrate (adhesive failure). To reduce the probability of these two failure mechanisms, these guidelines should be followed:

- The maximum extension of a sealant is generally required on a cold day when the adjoining cladding has contracted. Many sealants behave differently at different temperatures. Ensure that the sealant is able to undergo its maximum extension at the coldest temperature to which it will be exposed.
- The width of the sealant joint should be designed based on the expected movement of the wall and the movement capability of the sealant. For example, if the maximum movement of a wall panel is 6 mm and the sealant movement capacity is 25 per cent, the joint width should be 6 mm/0.25=24 mm.
- Generally, a sealant joint should be greater than 6 mm regardless of expected movement, to allow for proper application.
- Depth of sealant at the centre should generally be half of the width. A round foam backer rod should be used to provide the proper joint profile. Sealants should be bonded only to two surfaces on opposite sides of the joint. If a backer rod is used this is not usually a problem. If a fillet joint is used, a bond breaker tape should be used to allow joint movement to occur. Figure 7.10 indicates three sealant profiles commonly used in construction. W is generally 4 times the expected joint movement when high performance sealants are used.

TYPICAL USAGE

Table 7.11 shows applications for various types of caulked joints. The performance level is based on typical longevity when the sealant is installed in accordance with the manufacturer's instructions with proper backing and joint design, and when the joint is exposed to movements less than the sealant's allowable compressive and tensile movement capabilities. Users are cautioned that all sealants within a sub-group are not equal. They will have varying performance characteristics and longevity. Since no two sealants behave exactly the same, the user should consult the manufacturer's literature and test data for specific compatibility and adhesion information to each proposed substrate, as well as for ultraviolet resistance and specific application recommendations.

PAINTING AND EXTERIOR COATINGS

The selection of an appropriate coating can be a complex process. Performance is dependent on the class of paint selected, the particular coating manufacturer and product, the condition of the substrate, surface preparation, selection of an appropriate primer and the application. This discussion is intended to provide a general level of understanding only. The performance of individual coatings will vary considerably from one product to another within each class of coating. The *Architectural Painting Specification Manual* provides guidance on these performance issues for virtually all types of commonly used coatings.

Coatings are used primarily to decorate and to protect the substrate. Coatings such as elastomerics can also be used to increase the water penetration resistance of some substrates. Protection of the substrate is important but it is not a universal requirement because not all materials need to be protected. Ferrous and aluminum metal surfaces are the main substrates that require protection to reduce corrosion. Wood substrates are typically coated for appearance, however, most commonly used wood coatings will also provide

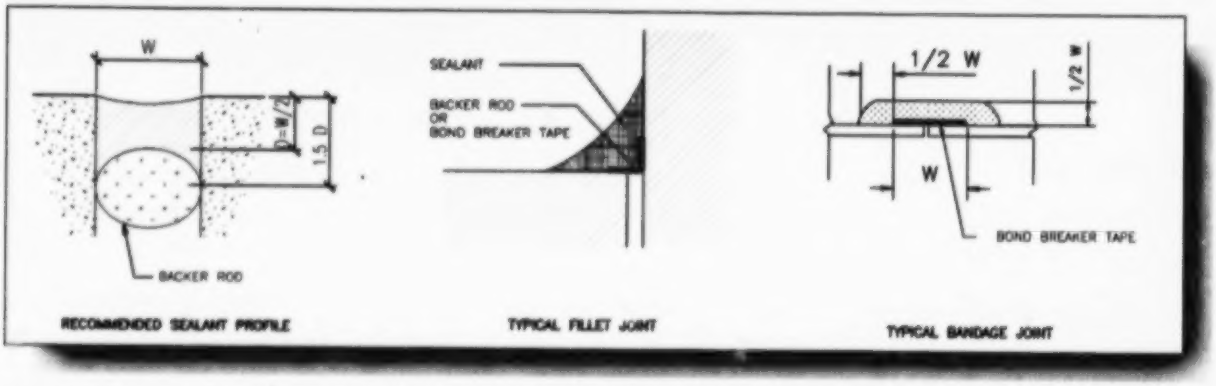

Figure 7.10: Typical sealant profiles

some level of protection and increase durability. Masonry is usually coated for appearance to provide a colour or texture, or to reduce wetting or water staining patterns.

Coatings are generally composed of three components: solvent, pigment and resin. The solvent thins the pigment resin mixture to application consistency. Pigment provides the colour and gloss adjustment. The resin or binder is the non-volatile portion of the paint that binds the pigment particles together and adheres the film to a surface, giving the paint durability and adhesion.

Coatings are generally classified according to their binder. The type of binder plays a large factor in the performance of the coating. However, the type and amount of pigment in a coating will also significantly affect its performance. The main types of binders and typical performance levels that can be achieved with proper pigments, surface preparation and priming are shown in Table 7.12.

The durability of coatings is dependent on many other factors besides the basic paint composition and application. Compatibility, protection and building design are additional factors that should be considered. Compatibility between substrate and coating is critical to the durability of the coating. For instance, alkyds and oil paints are not typically used on masonry because of fair to poor alkali resistance. When repainting, the existing paint composition should be determined so that compatibility with the new coatings can be checked to ensure long-term adhesion. The design of the protective elements of the building also have an impact on coating durability. Coatings always perform better on non-horizontal surfaces. Finally, the protective qualities of the coating should also be evaluated with the substrate deterioration mechanisms. Clear coatings on wood provide an example. Many clear coatings provide excellent resistance to water but some allow the transmission of ultraviolet radiation which degrades the underlying surface fibres of the wood. This results in peeling of the paint layer even under ultraviolet light resistant coatings.

The use of low permeance coatings, while not the cause of moisture-related problems in wall assemblies, can often contribute to the magnitude or severity of the problem by reducing the potential for drying. Some assemblies are more sensitive than others. Further discussion of this issue relative to specific assemblies can be found in Chapters 3 and 5.

Table 7.12: Comparison of Coating Binders (Adapted from Building Science [illegible] Materials in Use)

	Oil	Alkyd	Latex	Lacquer	Acrylic	Epoxy	Urethane	Vinyl
Film Properties*								
Gloss retention	P	E	E	E	E	P	F	VG
Yellowing	Cons	S	N	Mod	N	Cons	Cons	S
Adhesion	E	G	G	G	G	E	G	F
Hardness	P	G	F	VG	F	E	E	G
Flexibility	F	G	E	F	E	G	E	E
Moisture permeability	Mod	Mod	High	Low	Mod	Low	Low	Low
Resistance to:								
Abrasion	P	F	F	G	F	E	E	E
Water	F	G	G	G	E	E	E	E
Detergents	F	FG	FG	G	G	E	E	E
Acid	P	F	G	G	F	E	E	E
Alkali	P	F	G	G	G	E	E	E
Heat	F	G	F	F	G	G	G	P
Strong solvents	F	F	P	P	F	E	E	P
Substrate:								
Wood (pigmented)	G	E	E	NR	G	VG	E	NR
Concrete/ masonry	NR	NR	E	E	E	E	E	E
Metal (pigmented)	G	E	VG	E	G	E(Primer)	F	E
Metal (clear)	NR	E	NR	E	G	NR	E	NR
Surface prep for metal**	1	2	2	4	2	3	4	4
Service:								
Interior	G	E	E	G	F	E	E	NR
Normal exterior	G	E	E	G	E	E(Primer)	F	E
Marine	P	G	F	P	G	E(Primer)	E	E
Corrosive environment	NR	F	NR	G	F	E	E	E

*E = Excellent
VG = Very good
G = Good
FG = Fairly good

F = Fair
P = Poor
NR = Not recommended
N = None

S = Slight
Mod = Moderate
Cons = Considerable
GP = General purpose

**Surface preparation
1 = Easiest
4 = Most demanding

WATER SHEDDING ROOFING

Water shedding roofs are usually sloped more than 1:6 and drain water off the roof using shingled roofing. These roofs are very economical and effective at preventing water penetration. In this roof class, the roofing is usually divided into two types, standard slope and low slope. Reference is made to various installation procedures found in the Roofing Practices Manual.

ASPHALT SHINGLES

Asphalt shingles are by far the most frequently used roof covering for water shedding roofs. The most important characteristic is the quality of the shingle. This is determined not by the weight of the shingles but by the formulation of asphalts, the reinforcement and thickness. For this reason, manufacturers do not generally quote the mass of the shingles; rather, they compare the shingles based on their guaranteed life expectancy. A good quality shingle for use in new construction should be warranted to last 20 to 25 years to correspond with the expected durability of the whole roof assembly.

The most common type is the standard three tab strip shingle. Each shingle is adhered to the shingle below with pre-applied or field-applied adhesive. For high wind locations, interlocking shingles lock into the shingles below to provide an increased resistance to wind. Only interlocking shingles should be used on tongue-and-groove roof decks due to possible differential movement caused by changes in humidity, resulting in buckling of the shingles.

Once the shingles are selected, the installation of the shingles varies depending on the slope of the roof. On roof slopes greater than 1:3 use *Standard Slope Application STR-AS*. On roof slopes between 1:6 and 1:3 use *Low Slope Application STR-LS*.

CEDAR SHINGLES AND SHAKES

Cedar shingles and shakes have been used successfully in the coastal climate of British Columbia for many years. Both shakes and cedar shingles should only be used on roofs with slopes of 1:3 and greater. Eave protection is critical with the use of cedar roofs and should be applied in accordance with Detail 5 in Chapter 6 (page 6-18).

Cedar shingles are taper-sawn with a relatively smooth face and back. They are available in three lengths and four grades. It is recommended that No.1 (blue label) shingles treated with chromated copper arsenate be used. It is acceptable to use No. 2 shingles for the starter course only. The recommended specification for cedar shingles is *Shingle Application STR-CS*. For additional water penetration resistance, this application should be performed over solid sheathing and a layer of #15 roofing felt.

Cedar shakes are split from a log along the natural grain of the wood and have a highly textured surface. Shakes should be treated with chromated copper arsenate. They come in two lengths, one grade and three types. Hand split and resawn shingles have split faces and sawn backs to produce the taper. Taper split shakes are hand split and hand tapered. Straight split shakes are split along the wood grain and are not tapered. The recommended specification for cedar shakes is *Shingle Application STR-HS*.

CONCRETE AND MASONRY TILES

When considering the use of this roof system, the structure must be designed to accommodate the additional seismic and dead loads. Concrete and masonry tiles should only be used on roofs with slopes of 1:3 or greater. *Roofing Practices Manual* contains design information on this roofing system. However, the best references for material selection and installation are *Concrete Roof Tiles*, CAN/CSA-A220-M91, and *Installation of Concrete Roof Tiles*, CAN/CSA-A220.1-M91. The concrete and masonry tiles rely heavily on a watertight roof underlayment for watertightness. It is good practice to use a highly water resistant roof underlayment such as a #30 felt or multi-layered laminated product applied over plywood sheathing under battens on well-vented roofs. Consult the manufacturer's recommendations for appropriate materials.

METAL

Metal roofing is becoming more popular in residential construction and has recently been included in the *Roofing Practices Manual*. Metal roofing profiles are created by roll forming or break forming. Roll forming is a process of passing a sheet of metal progressively through a machine having powered circular roller dies. Each section of roller dies consists of an upper and lower matched profile. As the metal progresses through the machine, the metal changes shape from flat to formed. Break forming is a method of forming sheet metal by pressing it between two dies. Roll forming can be performed in the factory or on site with a portable forming machine. In general there is more quality control in the factory and as a result the quality of the factory finished product is more uniform.

The quality of the metal, the corrosion protection and the paint finish are important when selecting a metal roof system. Most paint systems incorporate a coating of a zinc-based alloy to provide cathodic corrosion protection of the base metal; this gives protection to the entire sheet and prevents localized corrosion where sheets are cut or penetrated. Once the cathodic protection is installed, a paint system is applied to provide a barrier coat to the aluminum zinc alloy as well as the aesthetic colour coating. The most common combination of coatings consists of sheet steel coated with an aluminum-zinc alloy and a 5000 series paint system. This system is suited for residential construction, but some bright and dark colours tend to fade and chalk over time. Once this happens, it may be difficult to match colours when replacement roof panels are required. On prestigious projects where better formability or fade and chalk resistance is required, the 10000 series paint system can be specified. Other more expensive coatings such as metallics are available but are not used commonly in residential construction.

The thickness of the metal sheet is dependent on the size and shape of the panels and the location of the supports. Consult the manufacturer's literature for the minimum thickness of the profile to resist structural loads and oil canning.

The most common metal joint is a standing seam. Standing seam systems perform well because they allow movement of the metal sheets and have concealed fasteners. Other profiles consist of batten seam and exposed fastener systems. Metal roof systems that incorporate concealed fasteners and standing or batten seams represent the best practice. These systems are fastened with clips to allow the roof to accommodate thermal movements in the metal. On exposed fastener roofs, thermal expansion and contraction of the roof panels often accelerates the deterioration of the seals at the fastener heads, allowing water to infiltrate under the roof sheets.

Condensation in metal roofing is a significant problem even in warmer climates. During clear nights, the metal panels radiate heat into space, lowering the surface temperature below the ambient air temperature. This can cause significant condensation on the underside of the roof sheets. To reduce problems associated with condensation and water infiltration, it is good practice to install a concealed fastener system over a continuously lapped sheathing membrane installed on solid sheathing. Exposed fastener systems should only be used in conjunction with an underlayment of non-breather type sheathing membrane on solid sheathing over a vented attic space.

WATERPROOF ROOFING

GENERAL

Waterproof roofing or low-slope roofing requires roofs to be sloped towards the drains. Best practice is to maintain a minimum 2 per cent slope to drain for all waterproof roof membrane systems.

The commonly used waterproof membranes can be divided into three main groups; bitumen built-up roof membranes, modified bitumen membranes and single-ply synthetic membranes. In general, the most effective method of ensuring the durability and quality of the roof is to select a Roofing Contractors of British Columbia 5-year guaranteed roof system. There are numerous roof systems recognized by the Roofing Contractors of British Columbia and they do not all provide the same level of performance. In addition, some membrane systems are better suited for particular assemblies and roof geometries. The membrane categories are summarized in Table 7.13. The relative strengths and weaknesses of commonly used membrane systems according to their physical parameters and installation is provided in Table 7.14 to assist in the selection of the most appropriate roof system.

BITUMEN BUILT-UP ROOF MEMBRANES

Bitumen built-up roof (BUR) membranes consist of two or more plies of reinforcement that are saturated in bitumen, assembled in place, and adhered to each other with layers of bitumen. The Canadian Standards Association recognizes three grades of asphalt: Type I, II, and III (*Bitumen for Use in Construction of Built-Up Roof Coverings and Dampproofing and Waterproofing Systems*, CSA A123.4-M1979). The asphalt types are designated by their softening point; the higher the type number, the greater the resistance to flow at elevated temperature and the lower the durability and water resistance. The most common reinforcements are organic felts, glass felts and spun bonded polyester. Organic felts will deteriorate if exposed to moisture, while the non-organic felts will not. Glass fibre felts have greater tensile strength than organic felts or polyester reinforcement, but have a lower elongation capacity than polyester felts.

A membrane with glass fibre felts is more difficult to install than a built-up roofing membrane with either organic felts or polyester reinforcement.

The performance of built-up roofing membranes can be improved by using modified asphalts in combination with high quality reinforcement.

Bitumen membranes must be protected from ultraviolet light. This is typically performed by spreading gravel into the final flood coat of asphalt.

Table 7.13: Summary of Membrane Features

Membrane Category	RCABC Warranty	Reinforcement Type	Number of Plies	Usual Attachment Method	Resistance to Ultraviolet Light
Bitumen built-up roofing	Yes	Organic felt Glass felt Polyester mat	3 to 5	Fully adhered with bitumen	Protect with gravel
Modified bitumen built-up roofing	Specific manufacturers and products	Glass felt Polyester mat	3 to 5	Fully adhered with bitumen	Protect with gravel
Thermofusable SBS modified bitumen	Specific manufacturers and products	Polyester mat Glass felt Polyester and glass	2 One ply acceptable if slope greater than 1:4	Fully adhered with bitumen Spot adhered with asphaltic adhesive	Granules pre-embedded in cap sheet
Self-adhesive SBS modified bitumen	No	Polyethylene sheet	1	Fully adhered	Protection required by design
Modified urethane	No	Glass fibre mesh/scrim	2	Fully adhered	Protection required by design
Vulcanized elastomeric	Specific manufacturers and products	None	1	Loose laid ballasted Fully adhered with adhesive	No protection required
Non-vulcanized elastomeric	Specific manufacturers and products	None	1	Loose laid	No protection required
Thermoplastic	Specific manufacturers and products	Polyester or glass fibre in centre of the membrane	1	Mechanical fasteners Loose laid ballasted	No protection required

MODIFIED BITUMEN MEMBRANES

The most common modifiers used for bitumen are:

- styrene butadiene styrene (SBS)
- styrene ethylene butylene styrene (SEBS)
- atactic polypropylene plastic (APP).

Atactic polypropylene plastic modified bitumen has a higher softening point than styrene butadiene styrene or styrene ethylene butylene styrene modified bitumen, but also becomes brittle at a higher temperature than SBS or SEBS modified bitumen. In general, APP modified bitumen is better suited to a warm climate, while SBS and SEBS modified bitumens are better suited to cool climates.

Table 7.14: Membrane Performance

Site Condition:	**Best Performance**	**Moderate Performance**	**Poor Performance**
Conventional roofs with complex curvatures such as domes, barrels, arches, etc.	8	3, 6, 7	1, 2, 4, 5
Inverted roofs with complex configurations with non-linear roof or curved layout and numerous penetrations, etc.	5	1, 2, 3	4, 6, 7, 8
Conventional membrane system	3, 6, 7, 8	1, 2	5, 4
Inverted membrane system	3, 6	1, 5, 7, 8	1, 2
Large uniform roof surface	3, 6, 7, 8	1, 2	4, 5
Slope over 1:4	3, 6, 7, 8	2, 5	1, 4
Zero slope		3	1, 2, 4, 5, 6, 7, 8
Physical Property:			
Puncture resistance	3, 8	1, 2, 7	4, 5, 6
Economic performance life	3, 8	2, 5, 6, 7	1, 4
Ease of maintenance	1, 2, 3	4	5, 6, 7, 8
Installation sensitivity	3	1, 2, 5	4, 6, 7, 8

1 Bitumen built-up roof
2 Modified bitumen built-up roof
3 SBS modified bitumen sheets 2-ply, torch-on
4 SBS modified bitumen 1-ply, peel-and-stick
5 Modified urethane
6 Single-ply vulcanized elastomer
7 Single-ply non-vulcanized elastomer
8 Single-ply thermoplastic

The modified bitumen category is subdivided into two main types, as follows:

- Thermofusable SBS modified bitumen sheets in a 2-ply application. Each sheet of the membrane has a glass-fibre or polyester reinforcement, or a combination of polyester and glass-fibre reinforcement. The plies can be adhered to the substrate and each other using hot asphalt or by heating with a torch. The second ply, or cap sheet, generally has granules embedded in the top surface to provide protection from ultraviolet light. When the roof slope exceeds 1:4, this type of membrane may be used in a single-ply application.
- Self-adhesive SBS modified bitumen sheets in a 1-ply application. This type of membrane is typically reinforced with a polyethylene sheet. The membrane is installed by pulling off a release paper and sticking the membrane to the substrate and itself at the laps. This type of membrane must be protected from ultraviolet light. This is typically performed by installing the membrane within wall assemblies or by covering the membrane with metal flashing.

SINGLE PLY SYNTHETIC MEMBRANES

Single-ply synthetic membranes can be subdivided into three main categories:

- Vulcanized Elastomers: The main distinguishing characteristic of a vulcanized elastomer is that it can only be bonded to itself by the use of an adhesive. Ethylene propylene diene monemer is the most common roof membrane in this category.
- Non-Vulcanized Elastomers: This category of membrane can be heat welded when it is new, but as it ages, it can only be bonded to itself by the use of adhesive because of vulcanization of the polymers. Chlorosulfonated polyethylene (CSPE or hypalon) is the most common roof membrane in this category.
- Thermoplastic: The main distinguishing characteristic of thermoplastic material is that it can be bonded to itself with heat or solvent. Polyvinyl chloride is the most common roof membrane in this category.

BALCONY AND WALKWAY PEDESTRIAN TRAFFIC MEMBRANES

There are two basic types of exposed membrane systems marketed for use on balcony and walkway surfaces: single ply vinyl membranes and liquid applied polyurethane.

VINYL

Vinyl deck membranes are similar but not the same as the polyvinyl chloride roofing membranes discussed in the previous section. Polyvinyl chloride roof membranes contain a layer of polyester or glass reinforcement in the centre of the membrane. This allows for a PVC-to-PVC connection at the lap joints that are heat welded together. Vinyl deck membranes are commonly manufactured by laminating the vinyl to a woven polyester reinforcement backing. When the seams of the membrane are hot air welded, this reinforcing can sometimes interfere with the bond between membranes at the lap joints. This generally reduces the strength of the lap seams when compared to PVC roof membranes and can result in premature leakage. The extent of this problem varies with the thicknesses of the vinyl and the reinforcement. Some vinyl manufacturers have eliminated this problem by producing membranes with the reinforcing in the centre, similar to the polyvinyl chloride roof membranes. These membranes will provide the best performance at lap seams and terminations.

Because of the reduced lap strength when compared to PVC roofing membranes and the effects of the reinforcing at the lap joints, it is important to ensure that no water is allowed to pond at laps or terminations of these traffic membranes. To reduce ponding, decks should be sloped a minimum of 2 per cent (after building settlement and shrinkage) towards drains. Lap joints in the membrane must be installed in a shingled application starting at the low point in the deck.

Vinyl deck membranes are installed in an exposed condition and are susceptible to physical damage. The thickness of the vinyl film and the adherence to the substrate are the most important factors to reduce physical damage. The minimum thickness of vinyl should be 1.2 mm (50 mil) with an overall membrane thickness of 1.5 mm (60 mil). The membrane must be fully bonded to the deck. Ensure that adhesives are compatible with the membrane used as well as any preservative treatment installed on the wood decking.

Scuppers and other metal flashings should be manufactured using polyvinyl chloride-coated metal. This product is usually available from the membrane manufacturer and can be heat welded directly to the deck membrane. This creates a seamless watertight link between the deck membrane and adjacent flashings.

POLYURETHANE

Exposed liquid applied polyurethanes have not had a good track record in wood-frame construction. The membranes are usually installed directly on the substrate with a reinforcing mesh installed over the joints in the deck sheathing. These systems perform adequately in concrete construction over non-living space because the concrete is stable and is resistant to deterioration if water penetrates the membrane. In wood-frame construction, the substrate expands and moves significantly more. Wood components are intolerant of water leakage and will move cyclically with moisture content and humidity. This movement often results in failure of the membrane at joints in the decking or at intersections in the membrane. Like vinyl membranes, these systems must be installed on the deck with a minimum 2 per cent slope towards drains. These membranes are not recommended over living spaces or over poorly vented exterior walkways and balconies, except where the surface is in a low exposure condition.

CHAPTER 8

QUALITY ASSURANCE

OVERVIEW

Quality assurance is a process to ensure that building envelopes of wood-frame buildings meet the intended performance expectations. At the same time that this Guide was being developed, CMHC commissioned the development of *Quality by Design: A Quality Assurance Protocol for Wood-Frame Building Envelopes in British Columbia.*

Quality by Design presents the quality assurance process throughout the entire design and construction delivery, from initial design development stages to the time the building is in service.

The flow of quality assurance requirements is presented and organized in *Quality by Design* with reference to a Quality Assurance Pyramid as shown in Figure 8.1.

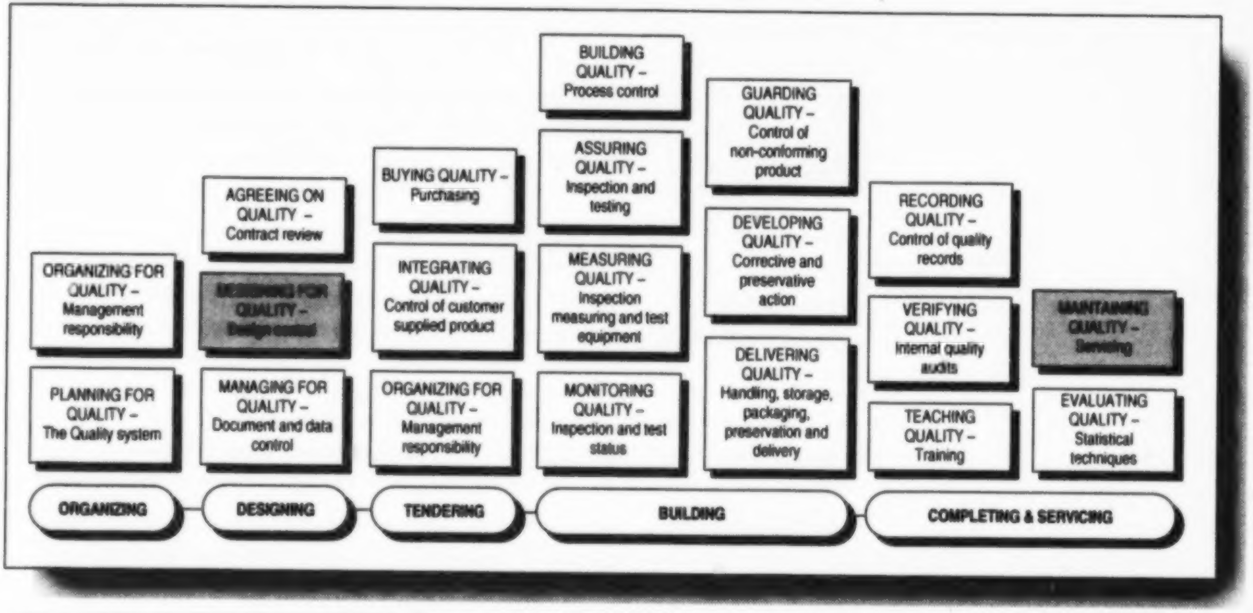
ORGANIZING FOR QUALITY – Management responsibility
PLANNING FOR QUALITY – The Quality system
ORGANIZING
AGREEING ON QUALITY – Contract review
DESIGNING FOR QUALITY – Design control
MANAGING FOR QUALITY – Document and data control
DESIGNING
BUYING QUALITY – Purchasing
INTEGRATING QUALITY – Control of customer supplied product
ORGANIZING FOR QUALITY – Management responsibility
TENDERING
BUILDING QUALITY – Process control
ASSURING QUALITY – Inspection and testing
MEASURING QUALITY – Inspection measuring and test equipment
MONITORING QUALITY – Inspection and test status
GUARDING QUALITY – Control of non-conforming product
DEVELOPING QUALITY – Corrective and preservative action
DELIVERING QUALITY – Handling, storage, packaging, preservation and delivery
BUILDING
RECORDING QUALITY – Control of quality records
VERIFYING QUALITY – Internal quality audits
TEACHING QUALITY – Training
MAINTAINING QUALITY – Servicing
EVALUATING QUALITY – Statistical techniques
COMPLETING & SERVICING

Figure 8.1: Quality assurance pyramid

Quality does not just happen. Every individual or organization involved in the design and construction of the envelope needs to organize for it. The purpose of *Quality by Design* is to provide guidance on establishing, maintaining and monitoring a quality policy.

DESIGNING FOR QUALITY

Building Envelope Design Control

The purpose of *Quality by Design* is to ensure that a project design meets the building envelope requirements of the client, the end user and society at large.

Building envelope design control occurs throughout the design phase. It influences programming, concept planning and design, site planning and detailed design. It consists of procedures and tasks that enable the designer to establish appropriate building envelope design requirements and to implement them throughout the design process. Key concepts include the need to define a water management strategy and to verify the performance of deviations from the recommendations presented in the Guide.

Quality by Design discusses the need to ensure that the 4-Ds (deflection, drainage, drying and durability) have been adequately considered in the design process. The 4-Ds are fundamental to the performance of building envelopes.

Quality by Design recommends that the assemblies and details presented in this Guide be the standard against which the design deliverables (design drawings and specifications) be compared. *Quality by Design* further recommends that any variances from the Guide be fully documented, including a discussion of why the design varies.

MAINTAINING QUALITY

Servicing

The purpose of this section of *Quality by Design* is to address the warranty periods provided in the construction contract. Part of this may be a maintenance and renewal plan as discussed in Chapter 9 of the Guide.

KEY POINTS

***Quality by Design* is a set of recommendations and guidelines that, if followed, will ensure an improved level of quality in design, construction and maintenance.**

- **The Project Quality Plan will be unique to each project.**
- **Quality does not just happen. Every individual or organization involved in the design and construction of the envelope needs to organize for it.**

CHAPTER 9

MAINTENANCE AND RENEWAL

OVERVIEW

Over the life span of a low-rise residential building, money is spent in four fundamental ways:

- **Initial Construction:** This includes the initial cost of constructing the facility, including professional and permit fees, and equipment that is an integral part of the facility.
- **Operations and Maintenance:** This includes all costs associated with the day-to-day operation of the facilities including physical plant staff, building maintenance, custodial services, utilities, landscape and grounds maintenance, security and traffic control, and other physical plant costs. Examples of routine maintenance activities for the envelope would include cleaning debris from roof drains, and inspecting and repairing exterior sealants.
- **Renewal:** This includes all expenditures to replace worn-out elements of a facility and are usually for items with life cycles in excess of one year. For example, a roof replacement is expensive but is likely to be required only every 15 to 25 years.
- **Adaptation:** This includes all expenditures required to adapt the facilities to the evolving needs of the users and to address new legislative requirements and standards. An example of this would be retrofitting to meet new fire safety requirements in multi-unit residential buildings.

The first category represents a one-time expense which has been the primary focus of the design and construction provisions of this Guide. The second category, while representing a significant part of the building owner's ongoing cash flow, should be relatively predictable and would not change significantly from year to year. (This does not mean that operations and maintenance costs shouldn't be reviewed so that tasks and expenditures optimize the building's life cycle costs.) The renewal and adaptation costs, on the other hand, are generally large and occur sporadically throughout the life of the facility.

Figure 9.1 gives an overview of the size of these costs over a significant part of the life span of a building.

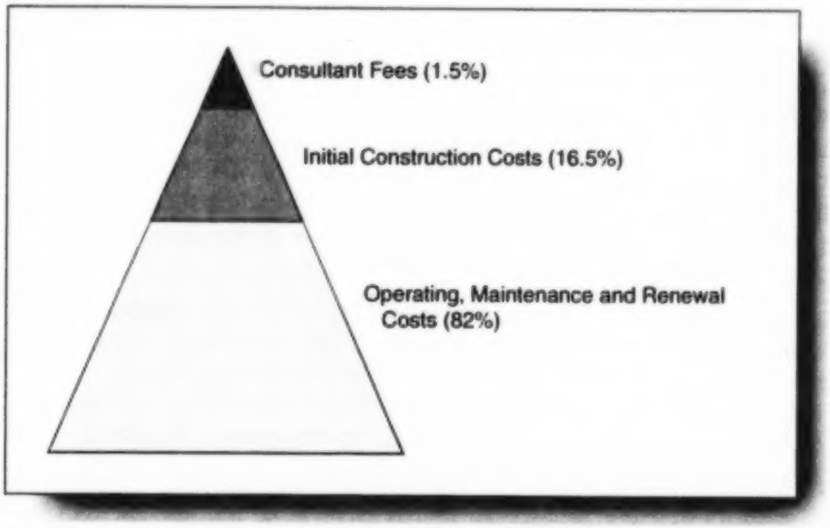

Figure 9.1: 35-year life cycle costs

Figure 9.1 clearly illustrates that most of the money spent on a building is spent after the initial construction. Unfortunately, in the case of many residential buildings, the responsibility for the costs of operations, maintenance, renewal and adaptation are handed over to a different owner group after construction. This removes much of the built-in incentive to optimize life-cycle costs that would exist if the developer was also the long-term owner.

It is also clear that achieving durable construction requires good decision-making during the design and construction phase. A rational plan for the operations, maintenance and renewal phases of a building's life need to be developed.

This Guide is focused on creating a durable building envelope. A logical extension of this focus is to provide guidance on maintenance and renewal so that the long-term owners of the building can continue to manage their building with durability and long-term performance in mind.

The development of a maintenance and renewal plan can best be provided by those most familiar with the building. It is therefore recommended that **an initial building envelope maintenance and renewal plan be developed for the eventual owners by the design team. It should form part of the project completion package and is similar to mechanical equipment maintenance manuals, warranties and as-built drawings which are all handed over to the owners to assist in the long-term operations and maintenance of the building.**

What follows is a discussion of the development of a maintenance plan and a renewal plan for the envelope assemblies. Similar plans could be developed for the entire building and integrated into one overall plan. Although usually presented as separate documents, maintenance and renewal plans are very dependent on each other. Poor maintenance could mean higher renewal costs or earlier replacement expenditures than would have been required if a more responsible maintenance plan had been developed. It is for this reason that it is critical to update both the maintenance plan and the renewals plan on a regular basis, usually every two to three years.

The concept of maintenance and renewal planning for an envelope assembly is very analogous to the life of automobile tires. Tires will provide 80,000 km of reliable service if regular care is given to inflation pressure, alignment and abnormal hazards (operations and maintenance). After 80,000 km, tires will continue to perform, although an inspection will show reduced tread and cracking on the walls. Continued use of the worn tires carries with it well-known risks, ranging from the inconvenience and cost of a flat tire, to injury and loss of life as a result of losing control of the vehicle at the time of a failure. Prudent automobile owners replace tires at the end of their useful life, and avoid exposure to unacceptable risks (renewal).

A more comprehensive discussion of durability, life-cycle costing and the relationship between initial design and construction, maintenance and renewals can be found in CSA S478-95, *Guidelines on Durability in Buildings*. Some aspects of maintenance and renewal are also discussed in *Introduction to Quality Assurance Protocol for Wood-Frame Building Envelopes in the Province of British Columbia*.

MAINTENANCE PLANNING

Maintenance of the building envelope will help to ensure that components and assemblies fulfill their intended functions and realize their intended service lives. Failure to maintain can result in damage to other envelope components and assemblies, including interior finishes, and reduce the structural capabilities of the envelope assembly. Maintenance planning involves describing inspection and maintenance tasks along with schedules for the undertaking of these tasks. The maintenance plan developed is unique for each building and must reflect the functional characteristics of each envelope assembly. For example, although this Guide discourages the use of face sealed wall assemblies and the reliance on sealants to control exterior moisture sources, the maintenance plan for such an assembly would be quite different from a plan designed for a rainscreen wall assembly which places little reliance on sealants to fulfill its intended functions. The sealant in a face sealed assembly would require frequent inspection and maintenance (once per year) while the rainscreen assembly may only require inspection every other year and sealant replacement or repairs every five years.

A maintenance plan for one particular assembly is shown in Table 9.1. It presents maintenance recommendations and associated time frames for a horizontal wood siding concealed barrier assembly (HS-1), which incorporates a vinyl concealed barrier window assembly (VY-1).

Table 9.1: Sample Maintenance Plan

Component	Recommendation	Time Frame
Wood Siding	Inspect finish on wood siding for evidence of staining, discoloration, fading, chalking or peeling. Maintenance activities could include repairs to item creating concentration of water leading to staining, localized refinishing or cleaning.	Bi-annual
Sealant	Inspect sealant for cracking, loss of adhesion, or bulging. Maintenance work may include replacement of sealant at some locations, or addressing excessive joint movements through modification of a detail.	Annual
Windows	Inspect hardware and weatherstripping. Adjust to ensure good operation and fit.	Annual
Doors	Inspect hardware and weatherstripping. Adjust to ensure good operation and fit.	Annual
Exhaust Vents	Inspect exhaust vent screens for lint collection. Clean if required.	Annual

The maintenance plan must reflect the competence of the individual undertaking the inspection of the component. For example, more specific guidance in the form of checklists and resulting actions would be required if a property manager or an untrained resident of the building undertakes the inspection, whereas very little guidance would be required for a professional who is regularly involved in the design, construction and maintenance of the building envelope. Guidance in the form of checklists for inspection of facilities is available in *Protocols for Building Condition Assessment*. Ideally, a customized checklist and resulting action list should be created for each individual building.

Inspection and maintenance activities may trigger renewals activities that will lead to changes to the renewals plan. For example, if frequent hardware adjustment is noted for windows, it may make sense to replace the hardware with less maintenance-intensive hardware.

The maintenance plan may also include operational guidance associated with components. In particular, the building's mechanical ventilation system should be addressed since it can have a significant impact on the performance of the envelope assemblies. Cleaning the exhaust vents in Table 9.1 is one such example. Another might be including instructions on when to use the bathroom and kitchen exhaust fans, or instructions on how to keep the interior relative humidity below critical levels. If repeated inspections identify humidity-related damage, this may prompt a recommendation to install humidistat controls on exhaust fans.

RENEWAL PLANNING

During the service life of a building, planning for renewal activities will identify the timing, cost and nature of the activity, as well as renewal activities required due to premature deterioration of a component. At the time of construction however, the plan will be largely based on theoretical or textbook knowledge of the usual life expectancies of various components and assemblies.

A renewal plan should also consider all elements of the building, not just the building envelope. Once the renewal needs have been identified, a funding plan can be established. Having a plan of this type allows for the gradual accumulation of the required funding through monthly fees, and eliminates the surprise of special assessments. It is usually considered adequate to plan for renewal expenditures that are likely to occur over the next twenty years. Forecasting beyond that time frame is difficult and it is unlikely that building owners will start to save for expenditures that will come up later than that.

It is common practice in most of Canada, although not yet in British Columbia, to have a study done by a qualified group of professionals to establish this plan and update it on a periodic basis. It is generally referred to as a Reserve Fund Study. The preparation of this type of study involves the same kind of expertise that provided the original design and specification of the assemblies.

At the time of the original construction, the plan is usually summarized in a tabular form similar to the one shown below. The entries provided are examples of what could be incorporated into such a plan.

The plan can be made much more detailed if desired. For example, it could include component and material specifications for each renewal recommendation.

Table 9.2: Sample Initial Renewal Plan

Item	Recommendation	Time Until Renewal	Renewal Cost
Roof	Replace roof and associated perimeter flashing	20 years	$100,000
Stucco Wall Assembly	Clean and recoat wall with new acrylic coating	10 years	$30,000
Stucco Wall Assembly	Replace sealants at window perimeters	5 years	$6,000
Windows	Replace insulating glass units	Phased–to be done as units fail over 10 years, beginning in year 15	$2,000 per year
Doors	Replace door hardware	10 years	$3,000

As mentioned earlier in this chapter, the renewal requirements are very dependent on the maintenance activities, as well as the quality of the original design and construction. **For this reason, renewal plans should be updated periodically, usually every two to three years**. At these times the condition of each component can be assessed and the timing and cost of the renewal activities can be adjusted to reflect the actual service condition.

KEY POINTS

- An initial building envelope maintenance and renewal plan should be developed for the eventual owners by the design team. It should form part of the project completion package and is similar to mechanical equipment maintenance manuals, warranties and as-built drawings which are all handed over to the owners to assist in the long-term operations and maintenance of the building.
- Maintenance of the building envelope will help to ensure that components and assemblies fulfill their intended functions and realize their intended service lives.
- During the service life of a building, planning for renewal activities will identify the timing, cost and nature of the activity, not just for the expected repair and replacement items but also for renewal activities required due to premature deterioration of a component.
- For this reason, renewal plans should be updated periodically, usually every two to three years.

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GLOSSARY

A number of the terms which are used in the *Best Practice Guide* have specific meaning in the context of this Guide and are therefore defined below:

Absolute humidity–In a system of moist air, the ratio of the mass of water vapour present to the volume occupied by the mixture, that is, the density of the water vapour component.

Air barrier–Materials and components that together control the flow of air through an assembly and thus limit the potential for heat loss and condensation due to air movement.

Air leakage–The uncontrolled flow of air through a building envelope or a component of a building envelope as a result of a pressure difference.

Assembly–Refers to the collective layers of components and materials which together comprise the complete cross section of the wall or roof.

Balcony–Refers to a horizontal surface exposed to outdoors, and intended for pedestrian use, but projected from the building so that it is not located over a living space or acting as a roof.

Base Flashing–Refers to the part of the roofing that is turned up at the intersection of a roof with a wall or another roof penetration. It may be made of the same material as the main roofing membrane or of a compatible material.

Building Envelope–Now called an environmental separator in Building Codes, refers to those parts of the building which separate inside conditioned space from unconditioned or outside space, and includes windows, doors, walls, roofs, and foundations.

Cap Flashing–Sheds water from the tops of walls. It is difficult to make metal cap flashing waterproof at joints and intersections, and it therefore requires a secondary, continuous and waterproof membrane below it.

Capillary action–The process of water movement through materials with tiny pores.

Cathodic protection–A method of preventing or reducing corrosion of metals by making the metal structure the cathode in a galvanic or electrolytic cell.

Celsius degree days–A measure of the departure of the mean temperature for a day from a selected reference temperature. Each degree Celsius of difference between the mean and selected temperature is counted as one degree day. For example, on a day when the maximum is 21°C and the minimum is 9°C, the daily mean is 15°C, and the number of degree days above 10°C is 5.

Cladding–Refers to a material or component of the wall assembly which forms the outer surface of the wall and is exposed to the full force of the environment.

Concealed Barrier–A strategy for rain penetration control that relies on the elimination of holes through a combination of the cladding and a secondary plane further into the assembly.

Conduction–Heat transfer through a material.

Convection–Transportation of heat by movement due to the ascension of air or liquid when heated and its descension when cooled.

Counter Flashing–Prevents water from penetrating behind the top edge of base flashing, and consists of a separate piece of flashing placed over the top of the base flashing. It is usually made of sheet metal.

Cross Cavity Flashing–Intercepts and directs any water flowing down the cavity of a wall assembly to the exterior.

Deck–Refers to a horizontal surface exposed to outdoors, located over a living space, and intended for pedestrian use in addition to performing the function of a roof.

Deflection–Refers to a water management principle that utilizes features of the building and assembly geometry to limit the exposure of the assemblies to rain.

Dew point–The temperature at which a given air/water vapour mixture is saturated with water vapour (that is, 100 per cent relative humidity). If air is in contact with a surface below this temperature, condensation will form on the surface.

Diffusion–The movement of water vapour through materials (including air) and caused by a difference in vapour pressure. It is not dependent on air movement.

Drainage–Refers to a water management principle that utilizes surfaces of the assemblies to drain water away from the assembly.

Drip Flashing–Directs water flowing down the face of vertical elements, such as walls or windows, away from the surface so that it does not continue to run down the surface below the element.

Driving rain wind pressure–The pressure caused by the highest five minute average wind speed (at 10 m above the ground) to be expected during a period of rain.

Drying–Refers to a water management principle that incorporates features and materials that speed diffusion and evaporation of materials that get wet.

Durability–Refers to a water management principle that utilizes materials that are tolerant of moisture.

Environmental separator–Refers to the separation of environmentally dissimilar spaces, most commonly indoor conditioned spaces and exterior unconditioned spaces.

Equilibrium moisture content–The percentage of moisture in the wood when it reaches a state of equilibrium with the immediate environment. This is always fluctuating and depends on the relative humidity.

Exterior Insulation Finish System (EIFS)–Composite type of cladding that consists mainly of externally applied rigid insulation board, glass fibre reinforcing mesh and synthetic stucco.

Face Seal–Refers to a strategy for rain penetration control that relies on the elimination of holes through the cladding.

Fibre saturation point–The point at which wood cell walls are saturated with water but the cell cavities are empty, usually about 28 per cent.

Flashing–Refers to materials used to deflect water and make water proof connections at interfaces and joints within and between wall and roof assemblies.

Horizontal Movement Joint–Refers to a horizontal joint on a wall which provides capability for differential movement of portions of the building structure (expansion joint) or prevents or localizes cracking of brittle materials such as stucco (control joint).

Housewrap–Refers to a sheet plastic material which is used as a breather-type sheathing membrane, generally between the wall sheathing material and the exterior cladding. Although at one time used as a proprietary term, housewrap is now used to represent a generic group of materials. One common type of housewrap consists of Spun-Bonded Polyolefin (SBPO), another is made of perforated polyethylene.

Hydrostatic pressure–The pressure in a fluid in hydrostatic equilibrium, that is, the pressure at a point due solely to the weight of the fluid above.

Kiln dried (KD)–Designation added by lumber manufacturers to indicate that the wood was dried in a kiln, a process that involves the rapid removal of moisture by the use of high temperatures. Kiln-dried wood has a moisture content of 19 per cent or less, usually between 15 and 19 per cent.

Maintenance–Refers to a regular process of inspection and minor repairs to the building envelope.

Moisture barrier–The moisture barrier is the surface farthest from the exterior which can accommodate moisture without incurring damage to the assembly.

Moisture content (MC)–The amount of water in a material such as wood, expressed as a percentage of the oven-dry weight of the material.

Operation–Of the building or envelope refers to normal occupancy of the building where the envelope is affected by interior space conditioning, changes to light fixtures, signs, vegetation and planters, and accidental damage or vandalism.

Oven-dry wood–Indicates that there is no moisture in the cell fibres or the cell cavities of the wood.

Penetration–Refers to a intentional opening through an assembly in which ducts, electrical wires, pipes, and fasteners are run from inside to outside.

Permeability–A measure of the ease with which water can pass through a material.

Pressure-treated wood–Wood that has been treated with chemical preservatives in order to make it resistant to deterioration caused by environmental conditions.

Rainscreen–Rainscreen refers to a strategy for rain penetration control that relies on deflection of the majority of water at the cladding but also incorporates a cavity that provides a drainage path for water that penetrates past the cladding.

Relative humidity–The percentage of the existing partial pressure of water vapour in a space to the saturation pressure at the same temperature, for example, air containing half the amount of moisture it is able to hold at a particular temperature has a relative humidity of 50 per cent.

Saddle–Refers to the junction of small horizontal surfaces, such as the top of a balcony guardrail or parapet wall, with a vertical surface, such as a wall.

S-DRY–A lumber grading term that describes the moisture content of the wood after it has been planed smooth; has a moisture content of 19 per cent or less, usually in the 15 to 19 per cent range.

S-GRN–A lumber grading term that describes the moisture content of the wood after it has been planed smooth; has a moisture content above 19 per cent and must be further seasoned prior to use.

Sheathing–Refers to a material (generally OSB or plywood) used to provide structural stiffness to the wall framing and to provide structural backing for the cladding and sheathing paper.

Sheathing Membrane–Refers to a material in an exterior wall assembly whose purpose is to retard penetration of water further into the structure once past the cladding. Waterproof type sheathing membranes can also perform the function of the air barrier and the vapour barrier. These materials include both breather type sheathing membranes such as sheathing paper and housewraps, and waterproof sheathing membranes.

Sheathing Paper–Refers to asphalt impregnated organic sheet material (breather type sheathing membrane) which creates a water shedding surface behind the cladding.

Stack effect–A phenomena caused by the density difference between warmer and cooler air (cooler air has a higher density). During the winter months this creates an outward acting pressure at the ceiling and upper walls levels and an inward acting pressure at lower level walls, leading to exfiltration of air at upper levels and infiltration at lower levels.

Stepped Flashing–Is installed at the junction between a sloping roof and a wall running parallel to the slope. Both base and counter flashing are overlapped and installed in pieces following the slope to form the complete stepped flashing.

System–Describes a combination of materials and components that perform a particular function such as an air barrier system, or moisture barrier system.

Thermal bridge–A low thermal resistance path connecting two surfaces.

Through-wall Flashing–Refers to a water proof membrane or metal flashing placed under segmented precast concrete, stone masonry or brick units known as copings close to the tops of masonry walls to prevent water from entering the wall at joints in the coping. Through-wall flashing is also used to prevent capillary transfer of moisture through porous materials such as concrete or masonry if they extend from high moisture locations such as below grade.

Valley Flashing–Is installed in the valleys of sloping shingle roofs to give continuity to the roofing system.

Vapour barrier–A material with low vapour permeability that is located within the assembly to control the flow of vapour and limit the potential for condensation due to diffusion.

Vapour pressure–A component of atmospheric pressure caused by the presence of vapour; pressure is expressed in mm of height of a column of water or mercury.

Walkway–Refers to a corridor exposed to outdoors which provides pedestrian access between suites and stairwells or elevators. It may or may not also be a roof.

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